CANADA'S NORTHLANDS

Ecological Land Classification Series, No. 0

CANADA'S NORTHLANDS

Proceedings of a Technical Workshop—To Develop an Integrated Approach to Base Data Inventories for Canada's Northlands

17-19 April 1974
Toronto, Ontario

SECOND EDITION

COMPILED AND EDITED BY

M.J. Romaine and G.R. Ironside

Ecological Land Classification Series, No. 0

Cat. No. EN 73-3/0

ISBN 0-662-10348-3

N° de cat. EN 73-3/0

ISBN 0-662-10348-3

PREFACE TO THE SECOND EDITION

These Proceedings were originally published as: Lands Directorate. 1974. Canada's Northlands: Proceedings of Technical Workshop -- To develop an integrated approach to base data inventories for Canada's Northlands, 17-19 April 1974, Toronto, Ontario (Comp. by M.J. Romaine). Lands Directorate, Environment Canada, Ottawa, Ontario. 298p.

The 1974 proceedings provided a comprehensive summary on data requirements in the north, and even today no comparable summary exists. Recommendations in this technical workshop resulted in, among other things, the formation of the Canada Committee on Ecological Land Classification.

Reprinting was done to satisfy a still existing demand for the original proceedings and to expose a wider audience to the results of this workshop. The original Proceedings have been adjusted to the format of the Ecological Land Classification Series, and the discussions, recommendations, and some papers have been condensed; otherwise, the Proceedings appear as they did in 1974. Addresses of contributors in the text indicate employers at the time of the workshop, whereas those in the 'List of Participants' are for latest employment (if known).

As they predate the Proceedings of the first meeting of the Canada Committee on Ecological Land Classification (Ecological Land Classification Series, No. 1), these Proceedings are assigned the number '0' in the Series.

PRÉFACE DE LA DEUXIÈME ÉDITION

La première édition de ce compte rendu a été publiée sous le titre de: Lands Directorate. 1974. Canada's Northlands: Proceedings of Technical Workshop -- To develop an integrated approach to base data inventories for Canada's Northlands, 17-19 April, 1974. Toronto, Ontario (Comp. by M.J. Romaine). Lands Directorate, Environment Canada, Ottawa, Ontario. 298p.

Le compte rendu publié en 1974 est une synthèse exhaustive des besoins de données pour le Nord et constitue, même à ce jour, le seul ouvrage aussi important dans ce domaine. C'est d'ailleurs aux recommandations faites lors de l'atelier que l'on doit, entre autres, la création du Comité canadien de la classification écologique du territoire.

Cette deuxième édition répond à une demande toujours actuelle et vise à faire connaître à un plus grand nombre de gens possible les résultats de l'atelier. La présentation originale a été adaptée pour correspondre à la 'Série de la classification écologique du territoire.' Quant au contenu, seules les discussions, les recommandations, et certaines communications ont été abrégées. Pour le reste, le compte rendu a la même présentation que dans la première édition. Les adresses des participants à la rédaction indiquent le nom de l'employeur au moment de la tenue de l'atelier, tandis que celles figurant à la liste des participants mentionnent le dernier employeur (s'il est connu)

Comme l'atelier a eu lieu avant la première réunion du Comité canadien de la classification écologique du territoire (N° 1 dans la 'Série de la classification écologique du territoire'), on a attribué à la présente publication le numéro 0.

* OPENING REMARKS

M.J. Romaine
Lands Directorate
Environment Canada
Ottawa, Ontario.

INTRODUCTION

About 70 people attended this Workshop. They represented federal departments, most of the provinces, and two universities. The Workshop was set up as a result of a recommendation made at the 'Canadian Northlands Data Needs Seminar' (Winnipeg, January 1974), and aimed to develop an integrated approach to base data surveys for 'Canada's Northlands' (the area of roughly 7,200,000 km^2 located north of the Canada Land Inventory boundary). Whereas the Winnipeg Seminar focussed on base data needs in northern Canada, this Workshop aimed to provide an update on recent advancements made in conducting integrated resource surveys and in applying recent technological advancements.

RATIONALE

The need for 'base data' has often been expressed. 'Base data' refers to basic information concerning the physical, biological, and human components of northern environments. Such information is required to protect and maintain the integrity of northern environments, including its people. It is also required to provide essential information on sensitive and fragile landscapes to ensure the engineering integrity of contemplated developments.

There are presently many proposals to tap the energy, mineral, and renewable resources of the extensive undeveloped hinterlands of the provinces and territories. However, base data are inadequate for almost all these areas. As these areas represent the last of Canada's frontiers, the manner in which they are developed concerns <u>all</u> Canadians. Adequate base data are necessary for the insurance of the best means of developing and managing these lands; efficient, comprehensive survey tech-

* This is a summary of the opening speech presented at the Workshop by the Chairman.

* ALLOCUTION D'OUVERTURE

M.J. Romaine
Direction générale des Terres
Environnement Canada
Ottawa, Ontario

INTRODUCTION

L'atelier a réuni quelque 70 personnes, qui représentaient certains ministères fédéraux, la plupart des provinces, et deux universités. Il est le fruit d'une recommandation faite lors du <u>Canadian Northlands Data Needs Seminar</u> (Winnipeg, janvier 1974), et son but était de mettre au point une approche intégrée des levés de données de base dans le Nord du Canada (soit la surface d'environ 7 200 000 km^2 située au nord de la limite des terres visées par l'Inventaire des Terres du Canada). Tandis que le séminaire de Winnipeg portait principalement sur les besoins en données de base pour le Nord du Canada, l'atelier visait à fournir une mise à jour des plus récents progrès réalisés dans la conduite de levés intégrés des ressources et dans l'application des derniers perfectionnements techniques.

BUT DE L'ATELIER

Le besoin de 'données de base' a souvent été évoqué; on désigne ainsi l'information de base portant sur les éléments physiques, biologiques, et humains des milieux nordiques. Ces renseignements sont nécessaires pour la protection et le maintien de l'intégrité des milieux nordiques, y compris les habitants. Ils sont également nécessaires pour procurer des données essentielles concernant des paysages sensibles et fragiles, données utilisées pour déterminer l'acceptabilité technique des projets envisagés.

De nombreuses propositions sont actuellement mises de l'avant, qui visent l'extraction des ressources énergétiques, minérales, et renouvelables que renferme le vaste arrière-pays inexploité des provinces et des territoires. Cependant, les données de base sont inadéquates pour la plupart de ces régions. Or, comme celles-ci représentent les dernières régions pionnières du Canada, tous les Canadiens se préoccupent de la façon dont elles sont mises

* Il s'agit d'un résumé de l'allocution d'ouverture de l'atelier qui était présentée par le président.

niques are thus necessary to provide this data base.

en valeur. Il faut donc recueillir des données de base appropriées afin de s'assurer que le développement et la gestion de ces terres profitent des meilleures méthodes possibles; par conséquent, il faut faire appel à des techniques de levés efficaces et d'ensemble pour recueillir ces données de base.

INTEGRATED APPROACH TO BASE DATA SURVEYS

There is no national consensus as to one system for collecting base data. Studies or programs vary because of differences in purpose, specialist inputs, and geographical location. The intent during the Workshop was to establish a framework under which the approach to future survey programs can be national in scope while allowing the actual mechanics and details to be tailored to the purpose of each project.

Many aspects are frequently considered under 'integration'. One deals with the fact that all of the environmental components of a landscape are related. To understand, sample, classify, and map one component, the interactions of others must also be known. Thus, to map the dynamics of vegetation, it is necessary to know related information on landforms, soil, climate, and moisture regimes. The need to integrate and relate the findings of one discipline to another is of paramount importance in northern areas where these relationships are often poorly understood. A second form of integration relates to the manner in which data are presented, either singularly or collectively (ie to what degree one interpretation can cover more than one environmental component, or how significant one map unit boundary can be to more than one discipline). This is a difficult concept to grasp, and even more difficult to implement. A third aspect of integration applies to the actual integration of programs; this infers a cooperative approach between participating agencies and disciplines in regard to purpose and goals. Logistic requirements (aircraft, fuel supplies, etc.) are extremely important in the north, and represent yet another form of integration.

This Workshop was not intended to dictate any preconceived method for collecting base data. The participants, as a combined group, represented a spectrum of interests and disciplines, with responsibilities ranging from program management to resource data collection, interpretation, and analysis. It was hoped that this wide range of expertise could be pooled at the Workshop to generate a first approximation to an approach for collecting base data, provide a framework for subsequent discussions on this subject, and provide initial guidelines

APPROCHE INTÉGRÉE DES RELEVÉS DE DONNÉES DE BASE

A l'heure actuelle, aucun système de collecte de données de base ne vaut pleinement pour tout le monde au pays. Les études et les programmes présentent de grandes variations à cause des différences que l'on retrouve dans le but des travaux, les apports des spécialistes, et les particularités géographiques. Pendant l'atelier, on visait à établir une structure capable de produire une méthode applicable à l'échelle nationale pour les programmes de levés, tout en permettant à la mécanique et aux éléments en place de servir spécifiquement les buts de chaque projet.

Nombre d'aspects sont fréquemment envisagés sous le terme 'intégration'. L'un d'eux concerne le fait que tous les éléments environnementaux d'un paysage sont solidaires. Pour comprendre, échantillonner, classer, et porter un élément sur carte, il faut également connaître les interactions des autres éléments. Par conséquent, pour illustrer la dynamique de la couverture végétale, il faut obtenir des renseignements connexes sur le relief, le sol, le climat, et les régimes d'humidité. Dans les régions nordiques, il importe au plus haut point d'intégrer les découvertes et d'établir la relation qui existe entre disciplines, puisque cette relation est souvent très mal perçue. Une deuxième forme d'intégration consiste en la façon de présenter les données, soit individuellement ou collectivement (c'est-à-dire qu'il faut déterminer à quel degré une interprétation peut couvrir plus d'un élément environnemental, ou établir l'importance d'une limite d'unité cartographique pour plus d'une discipline). Il s'agit là d'un concept difficile à assimiler, et encore plus difficile à mettre en application. Un troisième aspect de l'intégration porte sur une véritable intégration des programmes; il s'agirait d'une approche coopérative grâce à laquelle les organismes participants et les diverses disciplines adopteraient une méthode coopérative en ce qui concerne les objectifs généraux et spécifiques. Les besoins logistiques (aéronefs, approvisionnements en combustible, etc.) sont extrêmement importants dans le Nord, et ils représentent également une autre forme d'intégration.

for survey programs which are about to be implemented.

L'atelier ne vise pas à promouvoir une méthode préconçue pour la collecte de données de base. En tant que membres d'un groupe mixte, les participants représentaient une grande gamme d'intérêts et de disciplines, et leurs fonctions comportaient aussi bien la gestion des programmes que la collecte, l'interprétation, et l'analyse de données sur les ressources. On nourissait l'espoir que la mise en commun, à l'atelier, de ces diverses connaissances, permette d'élaborer la première ébauche d'une méthode de collecte de données de base, qui procure un cadre aux discussions ultérieures sur le sujet, et fournisse des directives initiales pour les programmes de levés que l'on réalisera très bientôt.

TABLE OF CONTENTS

DISCUSSION PAPERS

Moderator
R. J. McCormack
Director General
Lands Directorate
Environment Canada
Ottawa, Ontario

TERRAIN MAPPING IN NORTHERN ENVIRONMENTS

R.J. Fulton, A.N. Boydell, D.M. Barnett, D.A. Hodgson and V.N. Rampton
Geological Survey of Canada
Department of Energy, Mines and Resources
Ottawa, Ontario

INTRODUCTION

Most of the information required for a terrain analysis in northern environments is the same as that required for similar work in other parts of the country. The Terrain Sciences Division of the Geological Survey of Canada (GSC) does not view 'Northlands' terrain analysis as a special problem, 'Northlands,' however, do present particular logistical and access problems that influence the terrain analysis methodology, precision of data collection, and the cost of the work. Keeping this in mind, the following comments apply equally well to all parts of the country, and consequently our data collecting role in northern environments has not been distinguished from our other work.

GSC has been engaged in surficial geology studies almost since it was founded over 130 years ago. These studies have always been viewed as the part of the GSC work which deals with deposits of the latest time period, the Quaternary. Consequently, the techniques and standards developed for obtaining and presenting bedrock information have always been assumed to apply equally well to surficial geology. This view of surficial geology has gradually changed, firstly as it was found that the recognition and tracing of Quaternary geology units required techniques slightly different from those used in bedrock studies, and more recently as the demand increased for information related more specifically to land use planning and assessment of environmental impact. This paper is an attempt to state GSC's present concepts of the nature and scope of surficial geology studies.

The term *surficial geology* has generally come to mean the study of surficial deposits. As this is generally taken to exclude bedrock at or near the surface and excludes the present dynamics of the landscape, the term *terrain analysis* has been adopted as a more inclusive term for what we do. In our terms, terrain analysis includes: 1) a complete description of the form and character of the static land surface and the materials that immediately underlie it; 2) an analysis of the processes currently acting on or within the surface materials; and 3) an interpretation of the Quaternary history (in addition to providing a key to the stratigraphic or third dimension, this supplies information on previous processes and their rates).

The answer to why we should be interested in terrain analysis is simple. Terrain analysis concerns surface materials, and surface materials constitute the zone in which the biosphere is in contact with the lithosphere; they are the materials that we live on, from which we obtain most of our food and which we rearrange to meet our various engineering needs. A knowledge of the nature of surface materials, how they are being modified at the present time, and how they react under different uses is critical to all of our lives.

It is relatively simple to make a list of the data necessary for a meaningful terrain analysis. The difficulty is in organizing this information in a form that makes it readily available and at the same time makes it possible to group terrain units according to any one of the many parameters, to understand the relationships between terrain units, and to infer the Quaternary history. It is this situation of how to best organize the information around which most controversy and discussion revolve.

In evaluating schemes that we might use to organize terrain analysis information, several general criteria must be kept in mind:

1) The terrain elements identified must be based on criteria observable on aerial photographs. Logistic limitations often make it impossible to trace boundaries on the ground and hence units based on criteria that can only be obtained from the ground are impractical.
2) The scheme must be constructed so that it can be used equally well in all parts of the country. The composition of terrain units will vary from one part of the country to another but the scheme should be devised in such a way that someone

familiar with the coding system can easily understand terrain conditions in areas with which he is unfamiliar.

3) The system must be independent of the operator (ie it must be such that any two people would come up with essentially similar products).
4) The scheme must be independent of the ultimate use planned for the information. The emphasis should be placed on gathering fundamental data that completely describes the nature of the terrain. If this is done, then the data gathered should apply as equally well for forestry applications as it would for groundwater potential studies or engineering considerations.

GSC approaches terrain analysis from the point of view of modelling rather than that of classifying. To classify means to group or segregate into classes which have systematic relationships. Model is used in the sense of a complete description produced by a process of identifying and representing the salient aspects. Our main goal is not to provide a definitive study of the taxonomy of slopes, surface deposits, and landforms, but rather to provide an accurate abstraction of terrain conditions.

INFORMATION BASE

As stated before, a terrain analysis should provide three general things: 1) a description of the static land surface and the materials underlying it; 2) an analysis of the processes currently acting on the landform materials; and 3) a presentation of the Quaternary history. Once the information required for these prime items is in hand, it is possible to go one step further and predict how the area in question will react under any use.

To arrive at the three general items of the final analysis, specific information must be obtained relating to: 1) properties and conditions of surface materials; 2) geomorphology; 3) spatial relationships of surface materials; 4) processes; and 5) the historical context. Each of these is itself made up of several sub-items of information that are listed in Table I and further described below.

Properties and conditions of materials include the information that could be obtained from an exposure or a laboratory analysis of a sample. Under *texture* we are including the physical appearance or character of the material and the geometric aspects such as grain size, grain shapes and sorting. *Composition* is used here for the makeup of the materials in terms of lithology of rocks present, mineralogic composition of grains or character of organic material. *Moisture regime* refers to the intergranular water content, the nature of periodic variation of moisture content and to the state of the water. *Temperature regime* refers to the temperature of surface materials and its periodic fluctuations. *Reactive properties* is a general term used for measurements or observations that relate to the interaction of the other characteristics of the materials. Included in this would be engineering index properties such as Atterberg limits, shear strength, porosity, permeability, etc.

Morphology is concerned with form and structure. In morphology, in addition to items such as slope, the arrangements of slopes to produce landforms and the organization of the landforms, we are including relief or the differences in elevation, and drainage pattern. *Relief* is important as it is an indication of the potential energy available for fueling process activity and of the trafficability and construction problems that might be encountered. *Drainage* indicates the speed with which water is removed from an area including the orientation of drainage lines, so that some idea of trafficability can be obtained.

The *spatial factor* concerns the relationship of one type of surface material to another. *Stratigraphy* is a term commonly used for this relationship in a vertical sense, and material thickness is an important component. The *lateral* or *horizontal component* is the relationship of one surface material or landform unit to another in plan view or, in other words, the distribution on a map.

Processes are subdivided into two parts, the first being the *originating process*, that is the one responsible for producing the original landform, and the *modifying processes* or those that have acted or still are acting to change the surface. In addition to processes such as mass wasting and gullying which bring about major changes in surface materials and forms, modifying processes also include things such as flooding and avalanching which may cause little modification to the surface form but which are exceedingly important to anything living on the surface.

The *Quaternary history* category differs from the others in that the historical inferences are derived from the other information categories. To have a completely meaningful history, however, it is necessary to gather certain

additional things, such as samples for radiocarbon dating, elevation of erratics, and material for pollen analysis, which do not fit into the other information categories.

The information described above is obtained by *direct observation* and by *inference based on direct observation*. Direct observations can be taken from topographic and geologic maps and from aerial photographs, can be made on the landscape as seen in the field, can come from exposures or drill samples that give information from below the surface, or they can come from laboratories where samples can be analyzed and their physical properties measured.

Much terrain anlysis information comes from inferences. This means of obtaining our information is so common that we often do not give the inference a second thought, and may stack one inference on another to provide a piece of information two or three inferences removed from the original observation. An example of a direct inference is the assumption that a landform observed to have a delta shape is of fluvial origin; that it must therefore consist of sand is a second level of inference; a third level of inference is that, because of the other inferences, the delta-shaped landform would be covered by a well-drained soil (this final inference follows naturally from the assumption that the landform consists of sand, but is a giant step removed from the original observation that the landform was delta-shaped). In poorly accessible areas, however, this is often the only way to obtain soil information.

Table I lists three main categories of inferential information. 'Vegetation' and 'process' can be obtained by direct observation, whereas 'genesis' must be inferred from observations of factors such as morphology or texture.

Texture can be obtained by all three categories of inference. It can be inferred from the pattern and nature of vegetation and from vegetation density. The nature of the modifying processes and the way in which they have modified the landform (eg gullying, mass wasting, thermokarst, etc.) can also be used to infer deposit texture. As the delta example illustrates, a knowledge of landform genesis can be an excellent basis for inferring texture.

Stratigraphy can also be determined by using all three categories of inferential information. A line of dense vegetation on a steep hillside could be inferred to trace a spring line that marks the lower contact of a permeable bed overlying a less permeable material. Similarly, an observation that a process such as gullying affects the lower part of a slope differently from the upper could be used to infer a certain stratigraphic sequence. Finally, the delta example illustrates how genesis can be used to infer a certain vertical succession of materials. Deltas form where streams enter standing water, and deposition begins at the edge of the water body with finer material being deposited offshore. As time goes on, the coarse stream and delta topset sediments build out over the finer foreset and bottomset sediments; hence, from the inference that a delta developed in a certain way, one can infer a vertical succession of delta sediments.

INFORMATION GATHERING

The nature of information that should result from a terrain analysis has been outlined. This section indicates how a terrain analysis should be organized to obtain this information. This is not a description of how one of our projects has actually been organized, but is an outline of general planning and working principles that could be applied to terrain analysis in any area. The actual operation of such a program would depend on the resources available, the scale of the work, the nature and size of the area to be covered, the time available, and the experience and interests of the people involved. Table II lists the main steps involved in this example project.

A) Preliminary Planning

This step aims to define the general objectives of the project, determine the detail necessary, define the area to be covered, determine the resources required to carry out the work and set project timetables. This step should begin one or two years before the intended start of work so that all resources and materials will be available; hence, there will be no delays or handicaps once the main project is underway. This preliminary planning need only involve a person capable of running the project (preferably the eventual project leader), two or three user representatives, and clerical help capable of gathering information on available data and evaluating the adequacy of available airphoto and topographic map coverage. The necessary maps, airphotos and other similar materials would be ordered at this time.

B) Initial Data Compilation

This step aims to gather and analyse all available relevant information. The nature and the amount of information available and the resources required for processing it will have been determined during the preliminary planning. These factors will also have indicated the

Table I: Information Base

	METHODS							
	OBSERVATIONS AND MEASUREMENTS					INFERENCE		
	From Maps	From Airphoto	From Landscape	From Exposure	Laboratory Analysis	From Vegetation	From Process	From Genesis
<u>Properties and conditions of materials</u>								
Texture				x	x	x	x	x
Composition	(x)			x	x		x	x
Moisture Regime	(x)	x	x	x	x	x	x	
Temperature Regime		(x)	x	x		x	x	
Reactive Properties		(x)	(x)	x	x		x	
<u>Morphology</u>								
Slope and Arrangement	x	x	x			x	x	x
Association of Landforms	x	x	x					x
Relief	x	x	x				x	
Microrelief		x	x			x	x	
Drainage Pattern	x	x	x			x		
<u>Spatial relationships</u>								
Vertical (stratigraphy)		x	x	x		x	x	x
Hortizontal (contiguity)		x	x					x
<u>Processes</u>								
Originating		(x)	(x)	(x)	(x)			x
Modifying	(x)	(x)	(x)	(x)	x			
<u>Quaternary History</u>	(x)	(x)	(x)	(x)	(x)		x	x

x - measured directly
(x) - inferred from other direct observation

Table II: Steps in Information Gathering and Presentation

Step		Personnel		
		Professional	Support	Duration
A.	Preliminary planning	1	1	1 month
	1. define area to be covered 2. determine detail of work 3. determine resources necessary 4. order maps and airphotos			
B.	Initial data compilation	2 or 3	1 or 2	3-8 months
	1. analyse map information 2. abstract report information 3. compile raw information 4. subdivide area into broad physiographic units			
C.	Operation planning	1 or 2		2 weeks
	1. resource utilization plans 2. materials acquisition schedules 3. procedures and deadlines			
D.	Designation of terrain units			
	1. Office component - determine significant terrain units - plan detail study of terrain units	2 or 3	1 or 2	3-8 months
	2. Field component - obtain descriptions of terrain units by means of ground study	2 or 3	2 or 3	2-3 months
E.	Terrain mapping			
	1. Office components - set up map-units - perform airphoto interpretation - plan field checking	2 or 3	1 or 2	5-8 months
	2. Field component - field check airphoto interpretation - obtain terrain unit descriptions	2 or 3	2 or 3	2-3 months
F.	Information presentation			
	1. Finalize basic data map	1 or 2	1 or 2	1-3 months
	2. Prepare reports and derived maps	1 or 2	1 or 2	6-12 months

amount of time that should be devoted to this phase of the work. The project leader will have been appointed at this time, and he would direct one (or possibly more) junior specialist in doing the work. Table II lists three general types of information that should be the basis of this compilation.

The map information category is used for all types of portrayals that show plan view distribution of topographic features or landform materials and elements. Specific items would be topographic, bedrock and surficial geology maps and satellite images. Topographic maps would be used in subdividing the area into broad physiographic units. Satellite images could be used to augment the physiographic subdivision, to provide additional information on the geomorphic texture of the region and to give a first approximation of the probable nature and distribution of surficial materials within each physiographic unit. The bedrock geology maps would be used to give an indication of the probable compositions and textures of surficial materials and to give some idea of the relationship between bedrock type and topographic expression. Existing surficial geology maps would be used to add detail to the general physiographic picture, to verify preliminary ideas on the nature and distribution of surficial materials and to provide information on the type of map units that should be used.

Assembling existing report information requires a bibliographic search for all pertinent geology, soils, surficial geology, vegetation, engineering and process study reports that concern the project area, adjacent regions and areas of similar terrain lying in the same general climatic region. These specific reports should be perused for specific information on terrain features and materials that could be used in the analysis, for information pertinent to the geomorphic history of the area and for anything else that might give some idea of what was present in the project area or of how the terrain might be studied and subdivided.

The term *raw information* (Table II) is used here for specific data concerning the nature of terrain materials. This might be mechanical analyses of samples that were collected from borrow pits during highway construction, depths to bedrock obtained by seismic methods during damsite investigations or lithologic and stratigraphic information contained in shot hole or mineral exploration drilling logs. This data must be located, organized in a form that makes it readily accessible, and then synthesized for later use in the description of terrain features and materials.

The time required for compilation of existing data will depend on the size of the area involved and the amount of information available. In the case of large projects in areas in which a fair amount of development or exploration activity has taken place, this phase of work might require as much as a year. For small areas, and those for which there is little prior information, this phase of the work could possibly be combined with the designation of terrain unit stage of the project. The important thing to be accomplished by this work is to use available information to put together a good picture of major terrain elements, to develop a broad understanding of geomorphologic and Quaternary history, and to build up a bank of specific information that could be integrated into later phases of the work.

C) Operation Planning

The object of this phase of the work is to produce detailed plans including: manpower and other resource utilization; material acquisition schedules and deadlines; and procedures to be followed. This stage depends partly on the two previous phases. On the basis of time required and resources used, this phase is insignificant; however, as it sets the stage for all the following work, it is extremely important to the well-being of the project.

D) Designation of Terrain Units

The object of this phase of the work is to recognize and describe in detail the terrain units that make up each of the major physiographic units. The work involves an office phase followed by a field phase. Manpower and other resources required will depend on the size and nature of the area to be covered. Ideally all 'professional' participants who are to be involved in the field work should also take part in the office component. If the area which is to be covered is remote, such that the field work is fully supported by aircraft, it is not economical to use less than two people who are capable of independently gathering terrain information and three is probably a better minimum number to have involved. In addition to these professional specialists, the office phase would require one or two clerical-drafting helpers and the field component would require several field assistants in addition to a cook, aircraft

personnel, etc. required if it was a northern operation.

Office components - The object of the office component is to divide typical major physiographic units into constituent terrain elements. The idea is to determine the terrain elements that are present in each main physiographic unit rather than to subdivide all parts of the area into terrain elements. This can be accomplished by running airphoto interpretation transects across the main physiographic units. Following this, a compilation can be made of the terrain components present in the area and a search made for one or two field localities where typical examples of each component can be readily studied on the ground. Once the areas for specific ground studies of the components have been chosen, final plans can be made for the execution of the field phase of this part of the project.

Field component - The object of this field work is to obtain ground-based descriptive information on the nature of all terrain elements. The nature of the information obtained and the way in which it is gathered depends on the scale of the work, access, the size of the area, and the resources available for the project. If roads are present, these will be used as access to the terrain units, and hopefully much subsurface information can be obtained from roadcuts. If lakes and navigable rivers are present, boats and float planes may be used. If neither good road nor water access is available, the helicopter is the expensive alternative.

The size and complexity of the area to be covered and the proposed scale of the final product will control the intensity of the field project. Drilling should be an integral part of all but the broadest reconnaissance surveys as this particular ground truthing operation is in many areas the only way to obtain information from below the surface. Drilling, however, is an expensive and slow operation, especially where a helicopter is the only means of positioning the equipment.

The general method of work is to run ground traverses across all terrain units. Where roads are not available for access to the terrain units, fly camping is the logical alternative. The standard method of using fly camps is to choose a lake in the middle of an area that contains a number of different terrain units, put a small camp on the lake by means of a float plane, and then spend several days running ground and boat traverses from that camp. Areas without road access, without water access and that are thickly forested are not amenable to this traditional treatment.

Field information obtained for each terrain unit is organized into a bank of hard data. This is used in describing the area in the final presentation of data, to describe the nature of each of the terrain units and to aid in making decisions on which of the units are unique and which ones should be combined to form larger units.

E) Terrain Mapping

The object of this phase of the operation is to produce a map showing the distribution of terrain characteristics. The work again involves office preparation followed by field work. The same general manpower requirement is necessary as for the preceding phase, and it should involve the same people as they are already familiar with the work and the peculiarities of the area under study.

Office component - The object of this office component is to select the basic map-units that are to be used and to make an airphoto interpretation of all parts of the area. The selection of map-units is based on analysis of the information gathered during the earlier parts of the project and requires basic decisions on the best way to combine terrain elements to form practical yet meaningful map-units.

The airphoto interpretation or mapping of these units follows their selection and definition. Standard interpretation procedures are followed but as several 'interpreters' are involved in this operation, a method must be devised for assuring that all operators are mapping the same units. This may be done in a variety of ways but the result must be to force each operator to correlate his work with that of someone else relatively often. During the interpretation, a compilation is made of areas that should be checked in the field. These will include areas where the interpretation should be checked, places where additional descriptive information can be easily obtained and places where Quaternary history information is probably available.

Once the photo interpretation has been made of an area, this information is plotted on a map or mosaic so that a picture is maintained of the regional relationships of units. Making plans for the field work, which will follow, is the next step and these will be patterned largely to include observations at the places selected during the airphoto interpretation.

Field component - The objectives of this field

component are to verify the airphoto interpretation map, to obtain specific knowledge pertinent to the Quaternary history and to gather additional descriptive information on the nature of the terrain. The main difference between the way this field work is carried out and field methods used when defining the units is that this work is largely point specific (the other was area specific), and consequently the effort must be more mobile. The team carrying out the work should be the same one that did the previous work, and the general procedure would be to visit data points located during the airphoto mapping exercise to obtain specific items of information. In areas with good access, standard ground transportation could be used; in most northern areas, however, a helicopter is the only transportation which can supply the required mobility. The terrain map should be finalized as work progresses so that a manuscript copy of the final map would be available at the end of field work.

Should the necessary resources be available, a program of gathering further general terrain information can be carried out at the same time. The procedures used would be the same as those used during the first phase of field work, and drilling could even be done to supplement the descriptive information that was obtained during the earlier field work. The new survey information would be fed into the data bank set up earlier.

INFORMATION PRESENTATION

Gathering information is the most expensive phase of a terrain analysis; however, the money and work are wasted if the information is not made available to the public, or if it is presented in such a fashion that the user cannot get back what was originally put in. *Two aspects* should be presented: the basic model information, and the individual and derived aspects of the terrain analysis. The terrain model might be referred to as the base information document and the other presentations referred to as derived documents.

Base Information Document

Base information can be presented: 1) on a map, 2) on an extended legend, and 3) in a report. Table III shows the means by which the types of information that should be gathered during a terrain analysis can best be presented.

Map - A map is the most important part of the base data information. Even if other types of information portrayal are used, they must generally refer back to a map. Information can be presented in three general ways:

1) Landform symbolling with each symbol referring to specific terrain features (eg geomorphic mapping being done in Europe in which features and feature characteristics such as slope are shown by symbols; symbol colour is used to indicate the origin of the feature).
2) Letter symbols which indicate the origin, morphology and texture of the material in each map-unit (eg the Mackenzie Valley maps and the work currently being done in British Columbia — the letter symbols used to identify each map-unit indicate the nature of landform materials and the morphology; landform symbols are also used for specific features such as eskers, drumlins, etc.).
3) Named or numbered map-units (eg the Australian CSIRO system where land systems or map-units are simply designated by geographic names).

All of these methods have good points and drawbacks. The geomorphic type of map is good in that all terrain characteristics are presented separately so that the user can re-combine units according to any criteria he might like. It is excellent for areas of simple terrain or where a complex area can be shown at a sufficiently large scale. It does, however, tend to be a cartographic nightmare; and if the scale is small and the area complex, any pattern that might exist tends to dissolve into a myriad of overlapping, conflicting symbols and colours. Also, it is not easily adapted to reconnaissance work because the symbols do not lend themselves to generalization and cannot be used to show different levels of information input.

The CSIRO type of map is cartographically simple but presents the user with what is practically a derived map. He is dependent on the legend for all information as there is nothing about the name or number designation that in itself indicates the nature of the terrain. Also, this type of map is based on the 'type' map-unit.

The British Columbia-Mackenzie Valley type of map is a compromise between the other two. It is based on the symbol concept — letters are used on the map to indicate the characteristics of the terrain, but it is also similar to the CSIRO type of map in that map-units composed of specific mixes of terrain elements are outlined. The symbolling does require an intricately designed, rigidly applied format that uses carefully defined and applied terms; however, the cartographic problems are not as great as with the straight symbol or geomorphic

Table III: Data Presentation

Information	Method Presenting				
	Map		Extended Legend	Report	Data Bank
	Unique Symbol	Inferred from Another symbol			
Properties and conditions of materials					
Texture	x	x	x	x	x
Composition			x	x	x
Moisture Regime	x		x	x	x
Temperature Regime	x		x	x	x
Reactive Properties	x	x	x	x	x
Morphology					
Slope and Arrangement	x		x	x	x
Association of Landforms	x	x	x	x	x
Relief	x	x	x	x	x
Drainage Pattern	x		x	x	x
Spatial Relationships					
Vertical (stratigraphy)	x	x	x	x	x
Horizontal (contiguity)	x	x	x	x	x
Processes					
Originating	x	x	x	x	x
Modifying	x		x	x	x
Quaternary History		x	x	x	x

type of map because the information is not point specific. Even though both the British Columbia-Mackenzie Valley and the CSIRO ways of presenting map information involved drawing lines around areas of essentially homogeneous terrain, the map-unit symbol on the British Columbia-Mackenzie Valley type of maps indicates the specific characteristics of each outlined area so that the user knows exactly what to expect in each area.

Most workers in the Terrain Science Division of GSC started out using a CSIRO type legend with map-units designated by numbers and with certain specific features such as eskers shown as symbols. At present, however, there is a shift to the B.C.-Mackenzie Valley type of presentation with the same symbols still being used to show the location of certain specific features. This system is discussed in more detail because it is the map presentation that we have been using in the forested northlands. Appendix I provides specific detail on this symbolization as it is currently being used in British Columbia. The British Columbia-Mackenzie Valley type legend employs a four-part symbol for terrain element identification. The centre or core of this designation, referred to as the materials category, indicates the general nature of landform material. Morainal, marine, colluvial and rock are examples of the types of groupings used; others are listed and defined in the appendix. Most of the names used for these materials groups have a genetic connotation but there appears to be no more concise way of subdividing landform materials into broad, yet meaningful categories. Because these terms are genetic, they provide information on the process responsible for development of the landform materials; hence, in addition to defining the textural nature of landform materials in a broad way, they can be used to predict three-dimensional distribution of materials, textural variations, and, to some extent, landform expression.

One position in the designation is reserved for the texture of unconsolidated landform materials. The general materials category itself says a great deal about texture. Consequently, the position reserved for texture is only used when specific textural information is available. For instance, if a landform material is placed in the fluvial category, the assumption can be made that it consists of sand and gravel sized material. If no additional information is available, it is redundant to also indicate in the textural position that the landform material is sand and gravel. However, if an actual observation is made so that it is known that the particular landform in question consists of gravel, then it is worthwhile indicating this additional information in the textural slot.

A third unique position in the designation is reserved for a morphology term. General descriptive terms such as hummocky, ridged, plain and fan have been used, but difficulty has been experienced in keeping this position free from genetic interpretation. Also, genetic landform descriptive terms such as delta and beach sometimes creep in. What we have recently been attempting to do is to devise a number system for designating relief and slope so that morphology can be dealt with in a completely descriptive way. Terms such as fan, delta, beach, etc. could still be used but would be as much a refinement of the genetic term as a description of landform morphology. The landform or morphology part of the designation requires further work.

Modifying process is the final major item in our landform symbolling. Here we are dealing with two systems, one being static and the other being dynamic. The static system is what has been described above and is the landform material as it lies at the surface of the earth. The dynamic system is the processes that act to modify the landform. A blanket of loess is an example of a static landform. Gullying or deflation are dynamic processes that may have modified the loess blanket after it was formed or could still be actively remolding the landform. Appendix I lists the process modifying terms that we have used in British Columbia.

The combination of letters that makes up the symbol is bulky and appears somewhat onerous at first glance; however, because it is possible for a person familiar with the system to obtain an idea of the nature of the terrain by merely glancing at the map, we feel that it is preferable to using a single number or a name.

In addition to the map-units that are annotated by letter symbols, a number of specific individual features are shown by means of non-letter symbols. These are used for special items not easily incorporated in the map-units (eg flutings, landslide scars, striations) or for landforms of special significance that are too small to show as map-units. Some of the non-letter symbols that have been used in British Columbia are included in the appendix.

Extended legend - A legend is a necessary and integral part of any map. A normal legend on a surficial geology map would be made up of boxes that contain the symbols or colours that are used to designate the units on the map and

short paragraphs describing the texture, morphology and variation of the map-unit. Our extended legend is a table or matrix of parameters. The number of parameters considered is variable and depends on the orientation and scale of the project and the interest of the observers. The first column of the matrix lists map-units. The second column generally gives the textures associated with each map-unit. The third generally contains information on the morphology. Other columns have included engineering properties, vegetation, soils, ground ice content, comments on sensitivity, etc. — the number of columns that may be used is essentially limitless. This descriptive table or entended legend makes it possible to expand greatly on the information that is presented on the map and also organizes the descriptive information for each map-unit in a form that makes it possible for the user to quickly locate the specific data that he is interested in.

Report - No terrain analysis is complete without a written report. There is a final completeness in being able to present information verbally and in being able to add qualifying statements and generalities. Also there is some information that cannot be adequately portrayed on a map or extended legend. Locations where dynamic processes are acting can be shown on a map and some way devised to indicate their rate of operation, but the factors governing their action can only be described in a report. Ground ice can be mapped as a materials unit and its content in each map-unit can be listed in an extended legend, but in neither place is it possible to *explain* its distribution. Quaternary history should be put in a report. It is in part derived or determined from the terrain analysis map and it is possible to show the correlation of deposits, to draw the position of former ice fronts, and to outline former lake basins on the base document. However this further complicates an already complicated map and adds inferential lines to something that should largely be objective. Methodology used, the reasons for doing a certain area, the orientation of the work, and the general philosophy behind it can only be put in a report. Hence, even though most terrain analysis information can be presented on a map and an extended legend, a written report is necessary to give this analysis perspective and to convey certain information.

Automated data bank - The computer data bank will undoubtedly answer the problems of manipulating terrain analysis information and of tailoring it to specific users. All cartographic and terrain information could be stored in a single data bank and automated techniques used to construct an extended legend and to draw out specific information needed for reports. GSC has not experimented widely with automated data systems as a means of compiling and presenting terrain information, but the computer techniques have been used for several aspects of analysis.

Derived information - So far, only the physical information that is part of a terrain analysis and the presentation of this base data have been discussed. We often attempt to show so many different things on one or two base data documents that sometimes it is difficult for a user who is not highly trained to obtain the specific information he wants. This is not an apology for what we have been doing, as our goal is to construct one or two base documents that will contain all the fundamental terrain information. To make our work more usable, we must produce derived maps (aimed at the specific user) which will amplify the information presented on the base document.

We have produced a set of derived maps for the Fort Good Hope area. This set consists of a granular resource map which includes information on the type of bedrock lying near the river as well as information on the granular aggregates, a slope stability map for the banks of the Mackenzie River, and a terrain sensitivity map. Many other types of derived maps could be produced (eg slope maps, maps showing engineering properties, maps showing rates of processes, flood susceptibility maps, and maps showing areas that have been disturbed). However, either our surveys have been done too rapidly to permit us to gather the necessary detail or we have not had the resources to produce the maps. The extra resources required to turn out these maps would not be too great, if all cartographic and other data were stored in a computer managed data system. Once the information was in storage it would be relatively simple to ask the machine to sort through the data and provide maps showing single parameters. Until now, however, we have concentrated our effort on gathering the information and have given little time to thinking about how we can make this data easier to use.

CONCLUSION

We have definite ideas about the type of information that should be part of a terrain analysis. Our methods of gathering this data have varied, but I think that we now have enough experience to say how the data gathering phase of a terrain analysis should be run. We have pretty much arrived at a consensus about the way in which this terrain analysis information should be presented, but we still have

not been able to agree on all the details. In the past our prime concern was to collect reliable base data so that we could put together an objective base document. This was done on the assumption that the user would extract the information he needed. We see now that we will have to go beyond the source document and also provide some services of extraction and interpretation.

APPENDIX: TERRAIN ANALYSIS LEGEND USED IN BRITISH COLUMBIA

R.J. Fulton and N.F. Alley
Geological Survey of Canada
Ottawa, Ontario

The nature of each landform unit is described in terms of the nature and content of rock and unconsolidated material. These two major categories of landform materials are described separately because each has been treated in a slightly different manner. However, both are subdivided and described in terms of the same criteria — composition and geomorphology. An attempt has been made to base these subdivisions on objective descriptive criteria only. Individual units are referred to in terms of these criteria rather than by the specific landform names that have been used in the past. This is done to make the system flexible and easier to apply universally, to eliminate the confusion which arises when different names are applied to landforms that in a descriptive sense are the same, and to eliminate generic bias from the mapping of landforms. In addition, a term referred to as a modifying process is used so that the map unit designation contains a statement of the dynamics of the landscape as well as providing an objective description of the static features.

BEDROCK COMPONENT

Bedrock, the solid component of the landscape, may be included in the landform classification as: 1) a landform unit, or 2) underlying a cover of unconsolidated material. The method of treating the rock component will vary from one place to another and will depend on the information available, the scale of the work, the nature of the bedrock, and the intended use of the information.

Bedrock as a landform unit - Where mappable bedrock occurs at the surface, it is proposed that the bedrock component of landforms be subdivided on the basis of rock lithology, structure and the morphologic expression. The categories suggested for each are:

a) Composite
  - rock undifferentiated

  Igneous
  - intrusive acid (granite etc)
  - intrusive basic (gabbro etc.)
  - volcanic acid (rhyolite etc.)
  - volcanic basic (basalt etc.)

  Metamorphic
  - gneiss
  - schist
  - phyllite
  - quartzite
  - amphibolite
  - marble

  Sedimentary
  - coarse grained clastics (sandstone, conglomerate)
  - fine grained clastics (shale, siltstone, mudstone)
  - carbonates (limestone, dolomite)
  - evaporites (gypsum, anhydrite etc.)

b) Structure
  - flat lying
  - gently dipping
  - steeply dipping
  - folded
  - massive

c) Morphologic expression
  - hilly
  - rolling
  - hummocky
  - ridged
  - plain
  - steep slope (>30°)

The bedrock landform component name would be obtained by combining these expressions (eg a hilly area of massive acid igneous rock; a plain underlain by gently dipping basic volcanics; a ridged area consisting of carbonate and fine grained clastic rock; a steep rock slope).

Bedrock underlying a cover of unconsolidated material - Where the unconsolidated material is thick enough so that the role of bedrock in landform morphology is small, there is generally no need for noting the type of bedrock present; this information is available from a geologic map, and it is generally understood that rock everywhere underlies unconsolidated material at some depth. Where the unconsolidated material is thin, however, and bedrock does play a major role in landform morphology, it is often useful to indicate the nature and morphology of the bedrock. In this case, the bedrock component name could be written below that of the unconsolidated component. But here too the bedrock material need not be mentioned as long as the topography is adequately depicted on the map and there is no special reason for mentioning the presence of a particular rock lithology. In areas containing mainly bedrock, residual or colluvial material, which is derived from the underlying rock, is an important unit. The texture of this integrated bedrock is the most

important attribute of this material and this unit is treated as a cover of unconsolidated material overlying rock. Both types of material are included in the colluvial category, which is described below along with the other categories of unconsolidated materials.

UNCONSOLIDATED COMPONENT

Nature of landform material and morphologic expression are the main criteria used to subdivide the unconsolidated landform component. In this case the terms used for the broad compositional groupings are genetic terms. It is however felt that as the genetic terms used are broad and as the categories are defined by simple objective criteria, there should be little controversy over in which grouping most landforms fall.

Landform material categories (genetic categories)

- Unconsolidated materials undifferentiated.
- Morainal - variable mixture of boulders, gravel, sand, silt and clay deposited by glacier ice.
- Alluvial - sand, gravel, silt and minor coarser material deposited by flowing water.
- Lacustrine - silt, clay, sand and minor coarser material deposited in standing fresh water.
- Marine - sand, silt, clay and minor coarser material deposited in a marine environment.
- Colluvial - variable mixture of boulder to clay textured material deposited by various processes of mass-wasting and developed in place as a mantle of residual material.
- Organic - deposits predominantly of peat, muck, marl or other organic material.
- Eolian - sand and silt deposited by the wind.
- Volcanic - unconsolidated material deposited by a volcanic eruption (tephra).
- Firn - permanent and semi-permanent snow and minor included ice.
- Glacier Ice - ice formed largely through the accumulation of snow.

Additional groupings may be used to take care of boundary situations. For instance in some situations alluvial materials grade into marine, and morainal material (till) is so intimately mixed with alluvial material (glacio-fluvial) that the resulting deposits appear to have developed by an interaction of the two processes. Rather than erecting separate categories to handle these transitional materials it is suggested that the new groupings be referred to as combinations of the basic materials categories, such as alluvial-marine and morainal-alluvial.

Morphologic expressions

- Plain - relatively flat; unconsolidated material generally thick enough to cover irregularities in underlying bedrock.
- Apron - skirt of material accumulated at the base of a slope and in part on the valley floor.
- Blanket - relatively uniform cover generally 1 m or more thick which masks detail of rock morphology but which has a general form controlled by bedrock.
- Rolling plain - undulating topography; unconsolidated material generally thick enough to mask irregularity in the underlying bedrock.
- Hummocky - small but steep sided hillocks and hollows; unconsolidated material generally thick enough to mask irregularities in underlying bedrock.
- Ridged - small but steep sided linear hills and hollows; unconsolidated material generally thick enough to cover irregularities in underlying bedrock.
- Terraced - relatively flat surfaced feature terminated by an abrupt change in slope on one or more sides; unconsolidated material generally thick enough to mask irregularities in underlying rock.
- Fan - shaped like a fan with a noticeable slope towards the fan toe; unconsolidated material generally thick enough to cover irregularities in underlying bedrock.
- Veneer - thin cover of material of one genetic category on material of a different genetic category or on bedrock; material too thin to mask morphologic expression of underlying unit (up to 1 m).
- Complex - a mixture of several morphologic units (the nature of this unit generally must be explained in written text).
- Steep slope - slope >30° which is cut by erosion.

The name for the unconsolidated component is obtained by combining genetic category and morphologic expressions (eg morainal plain, alluvial fan, and terraced alluvial deposit). Glaciation is a factor which complicates the classification subdivision of most unconsolidated landform components. In the classification glaciofluvial, glaciolacustrine and glaciomarine are not recognized as landform materials categories distinct from alluvial, lacustrine and marine. However if positive evidence is available (either in morphologic expression or composition of the deposit) which indicates deposition adjacent to ice, glacio can be attached as a separate genetic consideration.

Unconsolidated component texture - The genetic category term defines unconsolidated landform component texture in broad terms, ie morainal

deposits consist largely of till, alluvial deposits are generally sand and gravel, and lacustrine deposits generally consist of silt and clay. In some instances, particularly where detailed information is available, it is possible to define deposit texture in more specific terms. The following textural modifiers are proposed for this purpose:

- Coarse bouldery - abundant material coarser than 1 m.
- Bouldery - abundance of material 1 m - 256 mm in size.
- Pebbly - dominantly gravel and coarse sand sized material (4 mm - 256 mm).
- Gravel - 1 mm - 256 mm material.
- Rubble - angular material boulder to granule in size.
- Sandy - dominantly granule and sand sized material (4 mm - .05 mm).
- Silty - dominantly silt with fine sand (.25 mm - .005 mm).
- Clayey - dominantly clay with fine silt (<.01 mm).
- Fine - silty and/or clayey material (<.25 mm).
- Diamicton - mixture of mud and gravel.

The textural modifier is merely added to the other two parts of the unconsolidated component term so that if a morainal plain is known to consist of a clay rich till, the landform component will be referred to as a clayey morainal plain; if an alluvial plain is known to consist dominantly of fine sand and silt, it will be referred to as a silty alluvial plain; etc.

EROSIONAL MODIFICATION

Both bedrock and unconsolidated landform components can show the effects of, or be currently undergoing, erosional modification by one or more processes. The nature of this modification and whether the modifying process is currently active should be indicated in the component name. Some erosional modifying terms that might be used are:

- Deflated - modified by the erosive action of wind.
- Glaciated - eroded or molded by glacial ice (to be used where unconsolidated material has been overridden by a glacier but not covered by morainal deposits).
- Washed - modification of a deposit or feature by the winnowing action of a body of standing water.
- Eroded - modification of a deposit or feature by a through-flowing stream.
- Gullied - modification of a deposit or feature by the cutting of channels and removal of material from along local drainage ways.
- Soliflucted - modified by the slow flowage of water soaked material from higher to lower areas.
- Congeliturbated - modified by heaving, churning or mixing due to frost action.
- Mass-wasted - modified by the down slope movement of loose material.
- Karst modification - modification by the subsurface removal of soluble materials.
- Avalanche modification - modification by the processes associated with frequent avalanche activity.
- Thermokarst modification - modified by the melting of ground ice.
- Piping modification - modified by the subsurface removal of particulate material.
- Nivated - modified by nival action.
- Biotic mounding - mounding due to biological activity (tree throw, animal burrowing etc.).
- Failing slope - modified by formation of tension fractures or the presence of large coherent masses moving slowly down slope.

A morainal plain that showed the effects of wave washing would be referred to as a washed morainal plain; a shale plain that was being dissected would be described as a plain underlain by fine clastic rocks subject to gullying; and silty alluvial deposits being modified by thermokarst processes would be referred to as a silty alluvial plain subject to thermokarst. Not all these terms may be useful and some will only be useful if they are narrowly defined. Mass-wasting, for example, covers a variety of processes by which materials are moved by gravity. All areas that are not completely flat are subject to some degree of mass-wasting. In this classification it is suggested that the term be restricted to slopes of such a nature that material, once loosened, will move freely away from its point of origin. An example would be a steep bare shale slope. Also, some terms will be used to indicate slightly different types of modifications in different areas but only through use will the bugs be ironed out and the terms given regional significance.

CONCLUDING STATEMENTS

This scheme is proposed largely as a method of mapping landforms. Hence the emphasis is placed on being able to describe the entire terrain objectively rather than providing names for minor features thought to be of great genetic significance. An attempt is made to eliminate names of genetic but not necessarily descriptive significance (such as end moraine, DeGeer moraine, beaches, outwash plain, etc.) and to use single terms for groups of deposits which in a broad descriptive sense are the

Table I: Rock Components

Morphologic Expression		Massive ⊕	Flat lying +	Gently dipping γ	Steeply dipping Ƶ	Folded ∩
hilly	y	⊕y	+y	γy	Ƶy	∩y
rolling	m	⊕m	+m	γm	Ƶm	∩m
hummocky	h	⊕h	+h	γh	Ƶh	∩h
ridged	r	⊕r	+r	γr	Ƶr	∩r
plain	p	⊕p	+p	γp	Ƶp	∩p
steep slope	s	⊕s	+s	γs	Ƶs	∩s

rock undifferentiated	R	quartzite	q
instrusive acid	ia	marble	m
instrusive basic	ib	amphibolite	a
volcanic acid	va	carbonate	l
volcanic basic	vb	evaporite	e
gneissic	g	fine grained clastic	f
schist	s	coarse grained clastic	c
phyllite	p		

same (ridged moraine used to include washboard moraine, rippled till, ribbed moraine, etc.; hummocky till used for moraine plateau, prairie mound, disintegration moraine; etc.).

As the proposed scheme uses the same morphologic descriptive terms for all compositional categories of unconsolidated landform components, and for all structural categories of the bedrock landform component, the two classifications can most easily be presented as Tables. The tabular classifications follow along with a suggested 'shorthand' system for designating the landform components on a map.

SYMBOL SYSTEM FOR REFERRING TO LANDFORM UNITS

In showing landform units on maps and in interpreting aerial photographs, a short method of designating landform units is required. All landform units and all possible variations could be listed and each assigned a number, but it would be necessary to continually refer to a Table when reading maps or interpreting aerial photographs. A system based on the use of letters or symbols, each of which stands for certain words of characteristics, is far more flexible and easier to use than a system that designates unique units by numbers.

Rock component - Table I gives the form and structures used in subdividing the rock components of landforms. This part of the landforms can be further defined by the use of prefixes indicating the above compositions.

Examples of designations of rock component of landform: a hilly area of granite would be designated as ia⊕y or massive acidic instrusive rock with a hilly landform expression; an area consisting of ridges of steeply dipping carbonate bedrock would be lƵr; a plain developed on flat-lying shale would be f+p; and a steep slope eroded in undifferentiated rock with unspecified structure would be designated as Rs.

Unconsolidated component - Examples of shorthand designations of unconsolidated landform components are given in Table II. Textural modifiers used are:

coarse bouldery -	cb	sandy -	s
bouldery -	b	fine -	f
gravel -	g	silty -	$\not s$
pebbly -	p	clayey -	c
rubble	r	diamicton -	d

If the texture is known, a textural modifier is used as a prefix (eg bCv — a veneer of colluvially derived boulders; cMp — a plain of clay rich till; and $\not s L^{G}_{h}$ — hummocky area of glaciolacustrine silt). In this last example, the G indicates that there was something about the deposit morphology or composition that indicated that it was uniquely glacial in origin. Glaciofluvial (A^G), and glaciomarine

Table II: Unconsolidated Components
Compositional Groupings (Genetic Categories)

Morphologic Expression	M-Morainal	A-Alluvial	L-Lacustrine	W-Marine	C-Colluvial	O-Organic	E-Eolian	V-Volcanic	U-Unconsol. undiffer-entiated
p-plain	Mp-morainal plain	A_p^G-glaciofluvial Ap-alluvial plain	Lp-Lacustrine plain	W_p^G-glaciomarine plain Wp-marine plain		Op-organic plain	Ep-eolian plain -loessal plain	Vp-tephra plain	Up
m-rolling plain	Mm-morainal rolling plain		Lm-Lacustrine rolling plain	Wm-marine rolling plain					Um
h-hummocky	Mh-hummocky moraine	A_h^G-hummocky glaciofluvial	L_h^G-hummocky glacio-la-custrine	W_H^G-hummocky glacio-marine	Ch-hummocky colluvium	Oh-hummocky organic			Uh
r-ridged	Mr-ridged moraine	A_r^G-ridged glacio-fluvial	L_r^G-ridged glacio-la-custrine	W_r^G-ridged gla-cio marine	Cr-ridged colluvium	Or-ridged organic	Er-ridged eolian		Ur
t-terraced		A_t^G-glacio-fluvial terrace At-alluvial terrace	Lt-terraced lacustrine	Wt-terraced marine					Ut
f-fan		Af-glacio-fluvial fan			Cf-colluvial fan				Uf
v-veneer	Mv-moraine veneer	Av-alluvial veneer	Lv-lacustrine veneer	W_v^G-glacio-marine veneer Wv-marine	Cv-colluvial veneer	Ov-organic veneer	Ev-eolian veneer -loessal veneer	Vv-tephra veneer	Uv
a-apron		Aa-alluvial apron			Ca-colluvial				Ua
b-blanket	Mb-morainal blanket		Lb-lacustrine blanket	Wb-marine blanket	Cb-colluvial blanket	Ob-organic blanket	Eb-eolian blanket	Vb-tephra blanket	Ub
s-steep slope									Us

x-complex can be used in morphic modifier position with any genetic category (ie Mx or Mhx) but the nature of the complex must be explained

F-Firn generally
I-Glacier Ice without morphologic modifiers

(W^G) are designated in this same way. If the genetic process responsible for the landform is still active an uppercase A is used (eg W_r^A would be a modern marine beach ridge and A_p^A would be a presently active floodplain). If there was a reason for emphasizing that a depositional surface was no longer undergoing active aggradation, an uppercase I for inactive) could be used (eg A_f^I would designate a fan no longer subject to active deposition). Table II shows some commonly used letter combinations.

Erosional modifier - If either the rock or unconsolidated component of a landform shows the effects of post-formation modification an erosional modifier is placed at the end of the component designation. Letters used to indicate the various types of erosional modification are:

D - deflated	E - eroded
G - Glaciated	V - gullied
W - washed	S - soliflucted
C - congeliturbated	P - piping
M - mass-wasted	N - nivated
K - karst	B - biotic mounding
A - avalanche	F - failing slope
T - thermokarst	

The erosional modifier is separated from the rest of the component designator by a bracket. For example Mp(T would be a morainal plain modified by thermokarst processes, Ap(G would be a floodplain deposit that has been overridden by ice, f m(V would be a rolling plain of shale that has been modified by gullying, and i p(K would be a plain underlain by gently dipping carbonates that have been modified by karst solution. An additional dimension can be added by designating whether or not the erosional process is presently active. For example: Mp(T^A would be a morainal plain currently undergoing thermokarst modification, Lp(P^A would be a plain of silty lacustrine material subject to piping at the present time, and f m(W^G would be a rolling plain underlain by flat-lying shale that has been washed (or bevelled) by a glacial lake.

Combining terms - Not all landforms can be mapped as simple elements. Where, for mapping purposes, it is not practical to separate out all pure elements, two or more single elements can be combined. For example, Mv Cv would be used to designate an area consisting of approximately equal parts of morainal veneer and colluvial veneer; Mvh would indicate an area consisting of about equal parts thin till and hummocky till; and MhA_h^G would be used for an area made up of equal parts hummocky till and hummocky glaciofluvial material.

Three categories of relative abundance are used where the landform does not consist of roughly equal parts of two or more elements: The first category is for the dominant element (or elements) of the landform unit and accounts for 60% or more of the unit area. The second category accounts for between 20% and 40% of the unit area, and the third for from 5% to 20%. Mv-gA_h^G for example would designate a landform consisting of at least 60% morainal veneer and between 20% and 40% hummocky glaciofluvial gravel. Mv-gA_h^G-Cv would indicate a landform made up of more than 60% of morainal blanket and from 5% to 20% morainal veneer.

If it is necessary to show that one type of landform unit overlies another, the one term is written above the other. $\frac{Av}{gAp}$, for example, would indicate a gravel alluvial plain overlain by a veneer of silty alluvium (overbank deposit); $\frac{Eb}{Mp}$ would designate a till plain overlain by a blanket of loess; $\frac{rCh}{gAp}$ would designate a rubble landslide deposit overlying an alluvial plain; $\frac{Mv{=}L^G}{Rh}p$ would designate an area consisting more than 60% of till veneered, hummocky undifferentiated rock and from 5% to 20% glaciolacustrine plain(s); and $\frac{MvCv}{Rs}$ would be used to indicate a steep slope of undifferentiated rock overlain by approximately equal parts morainal veneer and colluvial veneer.

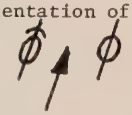
These categories put a 5% areal limit on the lower size of an element. This limit may be practical for sharply defined elements such as eskers or rock knobs, but in heavily forested areas with veneers, with areas of low relief outcrop, etc., an inclusion occupying as much as 20% of the area could be present without its being detected and mentioned in the landform designator.

SYMBOLS

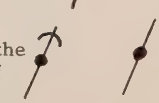
Drumlinoid trends — long axis orientation of:

1) drumlinoid ridges

2) crag and tail



3) flutings and other macro-features developed parallel to the ice flow direction (direction of ice movement known, unknown)

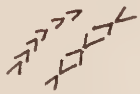


Glacial striae (direction of movement known, unknown; where number used 1 is the oldest)

Moraine ridge transverse to ice flow direction

Minor moraine ridges - washboard moraine, "annual" moraines and other till ridges transverse to ice flow direction

Esker - ridge of glaciofluvial material (direction of flow known, unknown)



Kettle hole - depression formed by the melting of ice buried in glaciofluvial or glaciolacustrine material (generally not used for depressions, possibly of similar origin, in till)

Subglacial meltwater channel (used only where very positive evidence that channel was formed under ice)

Abandoned or underfit valley (large, small)

Limit of submergence

Abandoned strands

Area beveled or washed by wave action

Dunes (active, inactive)

Deflation hollows

Block fields or surfaces strewn with boulders

Thermokarst depressions

Palsen

Patterned ground

Pingos

Escarpment in unconsolidated material

Landslide scar

Cirque

Filled or buried valley

Fault-line valley or trough

Sinkhole

Gravel pit (active, abandoned)

Quarry (active, abandoned)

Observation (ground, from air)

DISCUSSION ON THE PRESENTATION

Zoltai indicated that in setting up the idealized approach climate was neglected. *Fulton* responded that an idealized integrated approach was not established; the climatic information was required but they would not gather it. *McCormack* inquired as to how many different interpretative analyses relating to terrain sensitivity had been carried out in the Mackenzie. *Fulton* replied that it is difficult to say because everyone has a different interpretation as to what terrain sensitivity is. *Brown* asked what determines map area priorities. *Fulton* responded that both federal and provincial needs and their own needs determined the priority. No single item determines their own priorities; this is largely dependent on what type of expertise is available. The present priority is determined by the federal government on the basis of availability of funds. In response to a question from the floor regarding the kind of specialists that can undertake terrain mapping, *Fulton* indicated that to-date they have employed geologists and physical geographers. *Clark* felt that there would be no conflict as to what types of people were doing the mapping, as long as there is a good working relationship among the various disciplines.

ECOLOGICAL LAND SURVEY

M. Jurdant, J.L. Bélair, V. Gerardin and R. Wells
Direction régionale des Terres
Environnement Canada
Ste-Foy, Québec

INTRODUCTION

Land produces trees, agricultural crops, water, wildlife and aesthetic or recreational values. All these renewable resources of the land interact or compete in such a way that man can direct their productions according to his needs. Yet both the productivity of these land resources and the interactions vary in space and in time depending on the biological and physical characteristics of the land itself. A comprehensive and quantitative knowledge of the biophysical characteristics of the land is therefore a prerequisite to land planning and land management. Such a knowledge is obtained by an ecological land survey when it provides:

1) *A survey of the land itself*, which includes the *description, classification* and *mapping* of the following land characteristics:
   - climate
   - geology
   - physiography and landforms
   - texture, petrography and depth of the surficial geological materials
   - soil
   - biophysical characteristics of water bodies
   - structure, physiognomy, and composition of vegetation
   - succession of vegetation (chronosequences)
2) *Interpretations* of the biophysical characteristics of the land which are useful for land planning and land management. These are *land evaluation data* to be used by land planning users and land users to plan the use or deelopment of land. For example, in the forestry sector the following interpretations can be derived directly from an ecological survey.
   - The timber potential production — ie the upper limit of production which a given level of management can achieve. This limit is set by the environmental factors outside the control of management. This is the type of information provided by the forest capability maps of the Canada Land Inventory.
   - The forest succession following disturbances (fire, cutover, pests, storms, etc.)
   - The land capability for natural regeneration
   - The land capability for reforestation in disturbed areas (burned areas, abandoned farmlands, unregenerated cutover areas, etc.)
   - The land suitability for road location and road construction.
   - The trafficability.
   - The physical responsiveness to management treatments — ie erosion hazards, soil water table fluctuations, etc.
   - The biological responsiveness to management treatments — ie undesirable competition, lack of natural regeneration, etc.
3) *A better knowledge of the relationships between soil, climate and vegetation.* The discovery of such relationships allows a better understanding of the processes of biological production. Such a knowledge allows a more accurate translation of the basic biophysical data into predictions of performance or production. In summary, a land survey provides a framework of generalization about land which, according to Mabbutt (1968) "enables common character to be defined and described, and likes to be related although geographically separate. This is a prerequisite if there is to be any transfer of knowledge about land and any element of expectation in land use planning".

LAND — AN ECOLOGICAL SYSTEM

The Christian and Stewart (1968) definition of "Land" is used here in a comprehensive and integrating sense to refer to a wide array of natural resource attributes in a profile from the atmosphere above the surface down to some meters below the land surface. The main natural attributes are climate, landform, soil, vegetation, fauna and water. Land consists therefore of an assemblage of organisms in an

environment of air, water and soil. In other words, land is an ecological system in which complex interrelationships exist between organisms and the various components of the physical environment.

LAND SURVEY — A MULTIDISCIPLINARY SCIENTIFIC TASK

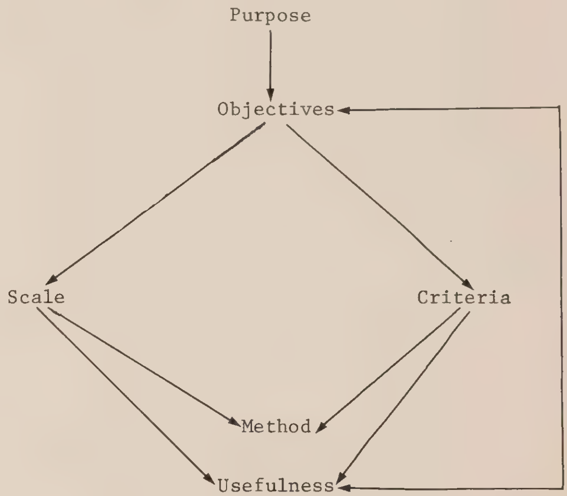
A land survey consists of the description, classification, and mapping of land. Emphasis is placed on the ecological whole rather than on the parts thereof. This is why environmental ecology is the science which a land survey is based upon, by integrating a host of information from climatology, geology, geomorphology, soil science, phytosociology, forestry, wildlife biology, etc. Consequently an ecological land survey is a multidisciplinary task. There must be a continuous exchange between the various specialists whose individual contribution must be centered around one goal: the identification of the key land parameters of biological production and the delineation of their spatial and temporal distribution. Too often so-called land survey teams are created which are merely groups of scientists working parallelly, providing separate information with limited use to the ecologist who tries to integrate the sectorial information into a land survey map. The limited use of the soil survey maps to the forestry sector is a good example of the problem involved here.

A land survey is a scientific task. The fact is unfortunately overlooked by many who consider all surveys as a 'technical' or 'cruising' type of work. An ecological survey is not merely a recording of *facts* that can be observed directly in the field or on aerial photographs. The individual members of the team as well as the team as a whole must develop a scientific model — ie a mental picture of the land, its constituent parts, their relationships and the reasons for the land being as it is. Land as an ecological system is infinitely more complicated than the carefully controlled systems studied by chemists and physicists in the laboratory. The accurate classification, mapping and interpretation of land can be achieved only through the scientific method. Thus, any assumption that ties the land survey personnel to a technician mentality automatically prevents the full realization of the objective of science, the discovery of new principles.

KINDS OF LAND SURVEYS

A land survey produces maps that subdivide broad areas into smaller ones. We do so to be able to make more precise statements about the mapped subdivisions of the region than we can about the region as a whole.

The *purpose* and *objectives* of an ecological survey dictate both the *scale* of the survey and the *criteria* of the taxonomic and mapping units. These, in turn, impose a *method*, but it is only through scale and criteria that the usefulness of the survey for the intended objectives and purposes can be evaluated. The relationships are as follows:



The relationships should never be forgotten when making decisions dealing with a program of ecological survey.

Assuming that the present program is designed to predict the biological potential production from a knowledge of the physical environment, the most important environmental variables which affect that production (ie climatic, physiographic, geological and pedological) must be selected as the major criteria of ecological classification.

The difference between an ecological land survey and a land capability survey (eg those produced by the Canada Land Inventory) should be emphasized here. A land capability map is an interpretative grouping of any available biophysical data (soil survey, ecological survey or more simply, the landscape features

themselves as seen from aerial photographs). It is based on 1) the knowledge available at the time of the survey concerning the relationships between the land characteristics and the capability of the resource considered (eg timber growth for the forestry sector), and 2) a given set of criteria for defining the capability classification selected at the beginning of the survey. The capability map does not provide information on the characteristics of the land itself. Therefore, any additional knowledge that would require a re-evaluation of the land characteristics or a modification of the classes themselves will jeopardize the accuracy and the precision of the survey itself. Since the ecological land survey provides an account of the land characteristics, it can be interpreted as many times as desired and by using any capability classification. It provides the basis for assessment of land capability not only for the requirements of today, but it is also capable of re-evaluation in the light of future requirements. An ecological survey provides an *inventory of the land and its resources* while the Canada Land Inventory provides an *inventory of the resources.*

LANDS SYSTEMS: SMALL SCALE ECOLOGICAL SURVEY (1:125,000)

This survey aims to delineate ecologically significant segments of the land surface, rapidly and at a small scale. This will serve as the ecological basis for land use planning involving future management of lands for forestry, agriculture, recreation, wildlife and water yields.

The ecological map is a comprehensive inventory of the most stable biophysical characteristics of the environment, which are significant to the potential production of the natural renewable resources and which determine the physical limitations to their management. It is the result of analyses, description and classification of the terrestrial and aquatic ecosystems of the region.

The basic mapping unit is the *LAND SYSTEM* which is defined as an *area of land throughout which there is a recurring pattern of landforms, soils, vegetation chronosequences and water bodies.* Each *Land System* is characterized by a:

- uniform regional climate
- characteristic relief
- characteristic pattern of landforms
- characteristic pattern of soils
- characteristic pattern of vegetation chronosequences
- characteristic pattern of aquatic ecosystems

The basic ecological classification was made by a multidisciplinary team composed of an ecologist, a geomorphologist, a soil scientist, a phytosociologist and a forester. It is derived from an *a priori* integration of the knowledge on vegetation, geology, geomorphology, soils and climate obtained during field and laboratory work. The classification and mapping of landforms on aerial photographs are used as the framework for a stratified sampling of benchmark ecosystems; these are selected to cover the full range of ecological conditions existing in the region. The descriptive and analytical data of soils and vegetation of these benchmark ecosystems are the basis of the classification of basic taxonomic units called *LAND TYPES.* The Land Type is defined as *an area of land characterized by a fairly homogenous combination of soil and chronosequence of vegetation.* The *Land Type* is the basic **cell** of the ecological classification. Each *Land System* can be considered as a recurring pattern of *Land Types.* The Land System map can therefore be considered as:

- An *ecological map,* since it determines iso-ecological units (ie units essentially similar in terms of the relationship between vegetation, soil and climate).
- A *soil association map,* since the mapping units are defined as a characteristic pattern of soil series.
- A *phyto-dynamic map,* since the mapping units are defined as a characteristic pattern of vegetation chronosequences.
- A *landform map,* since the mapping units are defined as a characteristic pattern of landforms.
- An *eco-climatic map,* since each mapping unit is comprised in a known Land Region (ie an area of land characterized by a distinctive regional climate as expressed by vegetation).

In the Saguenay-Lac-St-Jean region (Jurdant *et al.,* 1972), the Land Systems were mapped on aerial photographs at the scale of 1:30,000 and 1:40,000. They are identified on the map by means of symbols which express the most stable ecosystem elements at that level of ecological perception. However, each unit can be easily integrated to express soil or vegetation characteristics, by using the detailed description outlined in the publication.

Hereafter are the descriptions of two Land Systems located side by side in a mountainous area of the Laurentide Park. They are: RH1-12-1-h in the lower part of the valley,

and SM-1*1-1 in the surrounding mountains.

1) *LAND SYSTEM SM4-1*1-1-a*
Land Region (S): Hautes Laurentides. Compared to the other Land Regions of the Saguenay-Lac-St-Jean area, the ecoclimate is cold and wet. The regional vegetation is composed predominantly of balsam fir, black spruce and white birch. The balsam fir-white birch forest is the phytoclimax. The pedoclimax on well drained sandy loam till is an orthic ferro-humic podzol.
Relief: mountainous
Thickness of uncolsonidated surficial materials (4): shallow and deep
Major surficial geological materials (1*1): shallow till and deep till.
Land types:
ap3S: black spruce-*Hypnum* or white birch-balsam fir forest (fire) → balsam fir-white birch-*Hylocomium* forest (climax) on well-drained deep sandy loam till. The soil is an orthic ferro-humic podzol (Apica Series)
cy3S*: 10% black spruce-*Hypnum* forest (fire) → balsam fir-white birch-mountain maple-*Athyrium* forest (climax) on moderately well drained sandy loam till with seepage. The soil is an orthic humo-ferric podzol (Cyriac series)
bb2S*: 10% white birch-balsam fir forest (fire) → balsam fir-white birch-*Hylocomium* forest (climax) on well drained shallow till over bedrock; presence of seepage water. The soil is an orthic ferro-humic podzol (Babin Series)
lg3S*: 20% white birch-balsam fir-mountain maple (fire) → balsam fir-white birch-mountain maple-*Athyrium* (climax) on moderately well drained shallow till over bedrock; presence of seepage water. The soil is an orthic humo-ferric podzol (Le Gite Series)
gt2S: 20% black spruce-*Hypnum-Kalmia* forest on well drained very shallow till over bedrock. Presence of seepage water. The soil is a lithic ferro-humic podzol (Gatien Series)
be←2S: 10% black spruce-*Kalmia-Cladonia* forest on well drained bedrock outcrops. The soil is a lithic regosol (Bedard Series)
Aquatic Land Type: a. There is less than 5% of the area covered by water bodies
Area covered by the Land System: 38,185 hectares
Interpretation for management: see Table I

2) *LAND SYSTEM RH1-12-1-h*
Land Region (R): Moyennes Laurentides. The region is located at lower elevation and, consequently, the climate is warmer than in the Hautes Laurentides. The regional vegetation is composed predominantly of balsam fir, white birch and trembling aspen. The balsam fir-white birch forest is the phytoclimax. The pedoclimax on well drained sandy loam till is an orthic humo-ferric podzol
Relief (H): deep valley in mountainous areas of the Precambrian Shield.
Thickness of unconsolidated surficial materials (1): deep
Major surficial geological materials (12): middle slopes covered with deep till; bottom of valley covered with fluvio-glacial materials.
Land Types:
br2R: 10% black spruce-*Hypnum*, or aspen-mountain maple, or white birch-balsam fir (fire) → black spruce-balsam fir-mountain maple → balsam fir-white birch-mountain maple (climax), on well drained deep sandy loam till. The soil is an orthic humo-ferric podzol (Belle Rivière Series)
br2R*: 20% aspen-mountain maple, or white birch-balsam fir (fire) → balsam fir-white birch-mountain maple (climax). In warmer exposures: white birch-balsam fir-mountain maple-yellow birch (fire) → balsam fir-yellow birch-*Oxalis* (climax), on well drained deep sandy loam till; presence of seepage water. The soil is an orthic humo-ferric podzol (Belle Rivière Series)
cy3R*: 30% black spruce-*Hypnum* (fire) → balsam fir-white birch-mountain maple-*Athyrium* (climax) on moderately well drained sandy loam till; presence of seepage water. The soil is an orthic humo-ferric podzol (Cyriac Series)
ly2R: 10% aspen-mountain maple, or white birch-balsam fir, or black spruce-*Hypnum* (fire) → black spruce-balsam fir-mountain maple → balsam fir-white birch-mountain maple (climax), on well drained shallow till over bedrock. The soil is an orthic humo-ferric podzol (Landry Series)
lg3R*: 10% white birch-balsam fir-mountain maple, or aspen-mountain maple-*Athyrium* (fire) → balsam fir-white birch-mountain maple-*Athyrium* (climax); in warmer exposures, white birch-balsam fir-mountain mapple-yellow birch (fire) → balsam fir-yellow birch-*Oxalis-Athyrium* (climax); on moderately well drained shallow till over bedrock; presence of seepage water. The soil is an orthic humo-ferric podzol (Le Gite Series)
br1R: 10% black spruce-*Kalmia-Cladonia* (fire) → black spruce-*Hypnum-Cladonia* (climax) on excessively drained gravelly coarse sandy outwash. The soil is an orthic humo-ferric podzol (Bras-de-l'Enfer Series)
ci2R: 10% black spruce-*Kalmia-Cladonia-Cornus* (fire) → black spruce-*Hypnum-Cladonia* → black spruce-balsam fir → balsam fir-white birch-*Hylocomium* (climax) on well drained medium sandy outwash. The soil is an orthic humo-ferric podzol (Caribou Series)

Table I: Summarized Description and Interpretations for Management of Two Land Systems

Land System	SM4-1*1-1-a	RH1-12-1-h
Land Region	S: Hautes Laurentides	R: Moyennes Laurentides
Relief	M: Mountainous	H: Hilly
Thickness of unconsolidated surficial materials	4: shallow and deep	1: deep
Major surficial geological materials	1*1: shallow till and deep till	12: deep till and outwash
Water bodies	a: less than 5%	h: more than 5% covered by rivers
Total area	38,185 hectares	1,377 hectares
Area covered by water	1.2%	4.6%
Forest capability	5^5r 3^4 6^1mr	3^8 4^2mr
Mean annual increment	56 cuft/acre/year	72 cuft/acre/year
Potential timber production at 50 years	28 cunits/acre	36 cunits/acre
Agriculture capability	7^5rt 5^3pr 5^2pt	5^8pt 5^1s 7^1s
Ungulate capability	2^cmc	2^cm
Recreation capability	6P	5P
Landscape attractiveness	2	2
Recreation potential of water bodies	5	4
Water holding capacity of soils	$5^6 4^3 3^1$	$4^7 1^2 3^1$
Engineering suitability	5^5rs 4^3rs 3^2gs	3^5gs 2^3gp 4^2rs
Trafficability	5^5r 2^4tm 1^1	1^5 2^4mt 3^1tm
Erosion hazards	$3^5 2^4 1^1$	$2^7 1^3$
Windthrow hazards	$3^5 2^4 1^1$	$2^6 1^4$
Level of integration requirement	II F(O)	II F(O)

Aquatic Land Types: h-1285-42
h: more than 5% of the unit is covered by rivers having a width of more than 50 feet.
1: the shorelines are sinuous
2: moderate amount of rapids
8: backshore topography is abrupt and moderate
5: drainage system open shallow depth
42: shoreline materials; dominance of alluvial and fluvio-glacial sedments.

Area covered by the Land System: 1,365 hectares

Interpretations for management: see Table I

PRACTICAL APPLICATIONS OF AN ECOLOGICAL SURVEY

A) Land Survey and Land Use Planning

Land planners now recognize that the development of one renewable resource should not go forward in isolation, for it will affect the survival of others in the same area (Mabbutt, 1968). Therefore an ecological survey which provides a comprehensive and integrated study and classification of the land is particularly appropriate to the assessment of overall land potential. Unlike the Canada Land Inventory, the assessment of capabilities for forestry, agriculture, wildlife and recreation rests on one single biophysical basis — the ecological (or biophysical) map. It does not require an additional mapping procedure to recognize the possible land-use alternatives and to assess the land-use integration requirements.

B) Land Survey and Forest Management

Though the forester is more directly concerned with trees, the forest manager is becoming more and more a land manager. In addition to the knowledge of the composition and volume of the standing crop (provided by means of a forest survey), the manager needs a measure of the improvement possibilities to estimate the future forest composition and volume in relation to different levels of inputs. The latter is provided by an ecological survey which assesses:

1) The timber potential production
2) The successional trends (chronosequences) following disturbances (fire, cutover, pests, storms etc).
3) The land capability for natural regeneration.
4) The land capability for reforestation in disturbed areas (eg abandoned farmland)

The ecological survey also provides information useful for planning management practices, such as:

5) The land suitability for road location and road construction
6) The land trafficability
7) The physical responsiveness to management treatments (erosion hazards, soil water table fluctuations, etc).
8) The biological responsiveness to management treatments (undesirable competition, lack of natural regeneration, etc).

The ecological survey also gives a comprehensive account of the major restoration problems occurring in the surveyed area. It depicts the size and location of those areas which have the largest difference between present use and potential use. If these areas are large and close to roads, markets and labour, these are the ones that should be restored first for social, economical and political reasons. The ecological survey team is, in many instances, the only group of people who has a 'down to earth' comprehensive knowledge of the forests of the surveyed area; its expertise can therefore be of value in any decision relative to the management policies. The usefulness of an ecological survey depends on whether the forester is a harvester of trees or a land manager. The survey does not tell the forester what to do, but advises him on what would result from the use of certain management practices and combinations of practices, both in crop yield and the long term effects on the productivity on the land.

C) Land Survey and Integrated Resource Management

As clearly expressed by the sub-committee on multiple use of the National Committee on Forest Land, "Foresters (and forestry) are closely identified in the public mind with responsibilities in wildland management and should be actively concerned with integrated resource management" (Jeffrey *et al*, 1970). Since an ecological survey provides information relative to the ecological limitations to management, its completion is a prerequisite to a higher level of integrated resource management. The ecological survey is an integrated resource survey, prerequisite of integrated resource management.

D) Land Survey and the Protection of Environment

The ecological survey provides information which is required to permit the monitoring of ecological effects of resource exploitation. As an example, the SLSJ ecological survey delineates the areas of aspen forests which could be easily transformed into sugar maple stands with higher recreational value. There is no long term rational maintenance or

improvement of environmental quality unless land is properly managed, hence the link between the protection of environment and integrated resource management. A pilot project in integrated resource management would therefore be also a pilot project in environment quality.

E) Land Survey and Forest Resource Research

The practical applications of forest resource research findings are often limited because of a lack of a framework for extrapolation. The latter could be provided if the field experiments were placed in a land classification framework. Unfortunately, it is often when a project approaches completion that the forest scientist begins to think in terms of the representativity of his research area.

If a maximization of the cost-benefit ratio of a research project is desired, it seems logical that both the nature of the project itself and the selection of sites should give priority to land units which have a high timber production potential though a low actual production under the present management practices. Priority should also be given to those land units for which the least degree of effort is required to bring the actual production to a level corresponding to the potential production. The framework for determining this is provided by an ecological land classification.

F) Other Practical Applications

An ecological survey provides basic information for:

- Identification of fragile ecosystems (sensitivity maps)
- Identification of exceptional landscapes
- Assessment of the levels of complementarity and compatibility of the natural renewable resources
- Choice of agricultural crops
- Choice of areas best suited for roads, railways, airports, transmission lines, pipelines, dam sites, etc.
- Environmental impact analyses
- Planning of timber harvesting operations
- Choice of areas to be protected by ecological reserves, ecological interpretation centers, etc.

DISCUSSION ON THE PRESENTATION

Gimbarzevsky felt that the costs of such a program were too high. *Jurdant* indicated that 80% of the cost was for data collection. *Fulton* inquired as to the type of cooperation received from (eg civil engineers regarding road location). *Jurdant* replied that consultants are directed to his group by the James Bay Development Corporation.

Lee inquired as to how many studies had been carried out in winter. *Jurdant* replied that none had been carried out. Individuals had been undertaking their own specific studies on individual animals (caribou, beaver, etc.) and would be reporting on the land capability for that animal. The information he would like is the same boundaries of capability for beaver, caribou, etc. *Lee* then asked how they could advise on major development programs (eg hydroelectric power) if the information from the caribou and beaver surveyors is not input into his system. *Jurdant* replied that they provide a portion of the capability information that the caribou surveyor, for example, would require. *Lockhurst* inquired as to whether the individual doing the caribou survey would have an influence on how the data is collected. *Jurdant* responded that it would be affirmative for the long term but negative for the short term.

Brack asked who was studying aquatic factors. *Jurdant* stated that the rating system of waterbodies for biological production had not yet been worked out. He indicated the possibility of selecting a sample number of waterbodies and extrapolating. He also indicated that there were no studies of fish potential for the area except for fish population studies for specific lakes.

Jurdant indicated that they were in the process of discussing their work with the people responsible for managing the area. He felt that if they could indicate that money would be saved, then discussions regarding the use of their approach would likely be initiated. *Fulton* asked how much of the area was pretyped. *Jurdant* indicated that most of the area was pretyped prior to going into the field. This summer only areas around basecamps will be pretyped.

REFERENCES

Christian, C.S. and S. Stewart. 1968. Methodology of integrated surveys, p.233-280 *in:* Aerial Surveys and Integrated Studies. Proceedings of the Toulouse Conference (1964), UNESCO, Paris.

Jeffrey, W.W. *et al.* 1970. Towards integrated resource management. Report of the Sub-Committee on Multiple Use, National Committee on Forest Land.

Jurdant, M. *et al.* 1972. Carte écologique de la région du Saguenay-Lac-St-Jean. Notice explicative, Rapport d'Information X-F-X-31, Centre de Recherches forestières des Laurentides. Environnement Canada, Québec. 850p.

Mabbut, J.A. 1968. Review of concepts of land classification, p.11-28 *in:* Land Valuation. McMillan, Melbourne.

REMOTE SENSING FOR NORTHERN SURVEYS AND ENVIRONMENTAL MONITORING[1]

Jean Thie
Canada Centre for Remote Sensing
Department of Energy, Mines and Resources
Ottawa, Ontario

INTRODUCTION

Classification systems for mapping and describing the earth's surface evolved from single discipline oriented systems into integrated ones — from separate soil classifications, vegetation classifications, forest inventories and geomorphological systems, into ecologically based ones. In brief, an adequate survey system should:

1) be ecologically based
2) integrate water and land classification
3) describe present status
4) allow for monitoring of changes (natural or man-caused)
5) map and describe units for multidisciplinary resource planning and/or management
6) be rapid and inexpensive

Under the auspices of the National Committee on Forest Land, the development of a biophysical classification system for Canada was started. The aim was to differentiate and classify rapidly at a small scale ecologically significant segments of the land surface (Subcom. on Bio-phys. Land Class., 1969). It was recognized from the start that such a system should be ecologically based — mapping and describing land surfaces in such a way that judgments related to forestry, wildlife, waterfowl, recreation and agricultural (if applicable) potential could be made with little additional effort. The levels of classification proposed — land region, land district, land system and land type — appear adequate and flexible for most resource planning and management requirements as well as for impact prediction. One weakness of the system, however, is that it is a land-oriented classification system, and does not consider the integration of land and water. Water is an important resource in the North, from a recreational, fishing and wildlife point of view. A northern survey should pay proper attention to this aspect and integrate land and water classifications into manageable units. Also, while the biophysical system, because of its ecological basis, recognizes environmental changes and describes succession, more attention should be directed to present conditions and man-caused or natural changes.

The development of new remote sensors has added new dimensions to the survey of the environment. Multiband sensor packages aboard aircraft and satellite allow us to measure or map 'new' parameters such as surface temperatures, thickness of ice, air pollutants, etc., as well as enable us to better discriminate objects of interest. Repetitive remote sensing adds a time dimension to the survey, and the LANDSAT satellite, orbiting Canada four times daily and covering each part repetitively with an 18-day interval, can play a significant role in realizing an environment survey system that will be truly ecologically based, integrating land, water, atmospheric and biological phenomena as well as the interaction with living organisms including man. It is my intention to analyse and illustrate the operational and potential significance of remote sensing to northern resource data gathering.

AIRBORNE REMOTE SENSING

Interpretation of aerial photographs has been a common practice for most operational surveys (eg soils, landforms, forestry, crops, land use, etc). In the field of land classification, the photo interpretational inference techniques and extrapolations from selective field sampling have proven quite successful. In the Manitoba biophysical pilot project, an area of about 14,000 km^2 was mapped and described in less than 1 man-year (Zoltai *et al.*, 1970). The work was done by the interpretation of black-and-white photographs at a scale of about 1:63,000.

The important information stored on an image, and used for classification, is relief, shape, tone and texture (or 'signature'). Relief and

[1] Technical Paper 74-13, Canada Centre for Remote Sensing.

shape especially contain valuable information for inferring conditions which cannot be 'seen' directly; tone and texture help to differentiate between objects. Airborne remote sensing adds little if anything to the relief and shape information. Its main value lies in increasing the contrast of surface features — it may make certain parameters visible which we cannot see with our eyes or by conventional photography. For example, infrared photography helps to detect stress symptoms in plants (disease, moisture, etc.) and generally provides very good discrimination between vegetation types. Different studies have indicated that 1:120,000 scale colour infrared imagery can provide the equivalent amount of information as 1:60,000 black and white (Thie, 1971). This smaller scale can reduce mapping most for interpretation, while the more synoptic view (about 640 km^2) provides a superior base for land system and district analysis. Multiband photography can be valuable for land and water classification systems. It would enable the simultaneous use of water penetration film (colour or blue-green) and land-vegetation film filter combinations (colour or colour IR with different filters).

Multi-spectral scanners on board aircraft may be of some use in the future. Their theoretical advantage is that they can measure the radiation in a very narrow 'band' of the electromagnetic spectrum and can therefore optimize the spectral reflectance differences between objects. Computer handling and interpretation of data is presently quite costly, so much so that instruments of this nature are of little operational interest. Single-channel or dual-channel scanners, especially in the thermal infrared of the spectrum, however, seem advantageous to include in a sensor package. It allows mapping of temperatures to about 0.5°C during the day and night. Repetitive flights with such instruments can be used to describe and measure the temperature regime of land types over time (eg frost pockets or exposure influence) and help approximate microclimate over large areas at low cost. It can also be used for the detection of ground water discharge areas, incipient forest fires, water pollution, or lake surface temperatures.

The value of side-looking radar imagery for land classification purposes is still uncertain. Experience with it in Manitoba (Thie, 1974) showed little promise for mapping land systems, although cultural features such as farm fields and buildings, transmission lines, etc. could be successfully mapped. A number of new sensors are being developed, such as the HISS radar (Holographic Ice Surveying System) and soil moisture meter. If successful, these systems will be able to add important quantitative data. Laser fluorosensors, presently under development, will be useful for bathymetric surveys in shallow water areas, for fish tracking, and for monitoring oil slicks and dyes on water. LIDAR, optical probing of the atmosphere with a high-power laser source, may add significantly to a limnological or atmospheric survey (MacDowall and Lapp, 1973).

SATELLITE REMOTE SENSING

Satellites, such as the earth observation satellites (LANDSAT - previously ERTS) and some weather satellites (eg NOAA) should be considered for use in the north. Both can be received directly by the Canadian Receiving Station in Prince Albert, Saskatchewan. The characteristic difference between the two types is in scale, resolution, and frequency of orbit. LANDSAT satellites have a 4-channel multispectral scanner which registers in the Green, Red and two near-infrared bands of the spectrum. The NOAA satellite provides, in addition to this, thermal 1R scanning.

Scale and Resolution

The scale of imagery produced from LANDSAT is 1:1,000,000. Photographic enlargements to 1:250,000 and even 1:125,000 provide high quality imagery for interpretation and mapping. The biophysical land classification system suggests the following mapping scales for its levels:

Land Region-1:1,000,000-1:3,000,000
Land District-1:500,000-1:1,000,000
Land System-1:125,000-1:250,000
Land Type-1:10,000-1:20,000

The resolution and scale of LANDSAT seems suitable for mapping at the first three levels. Considering that on the computer compatible tapes from LANDSAT the minimum resolution of 1 pixel represents 76.2 m x 76.2 m on the ground, even some use for land type mapping can be expected. In the Churchill and Mackenzie areas (Tarnocai and Thie, 1974), LANDSAT provided very detailed information from computer tapes, and the major problem encountered was in reducing this amount of data into significant larger complexed units. This can be done by using human or automated interpretation techniques. At present the human based ones are more effective, certainly for biophysical type of classifications. The scale of the NOAA imagery is extremely small; one picture covers about half of Canada. Although the resolution is much poorer than LANDSAT, high contrast

phenomena can be monitored effectively (eg snow and ice, large burn areas in winter).

Repeated Coverage

The NOAA satellites cover Canada every day, and LANDSAT has an 18-day interval between passes over the same area. For the high north, successive coverage up to five days can occur. Repeated imaging of the same area throughout the growing season, through winter and over a number of years will help access and define the dynamics of our environment. This is an aspect which has been missing even in most ecologically based surveys, though vegetation succession may have been described. Seasonal imaging will help in relating phenological phenomena, disease development, moisture stress symptoms, snowmelt, and ice movements to other physiographic parameters such as landforms, soil, relief, exposure, water, etc. Winter images can enhance particular surface phenomena such as snow cover, and low sun angles enhance relief and fracture interpretation. Winter imagery in the Moose Lake area in Manitoba showed a good discrimination between black spruce and jack pine vegetation types. These are difficult to separate on summer images and even on conventional black and white photography with a scale of 1:63,000. The time of the year changes the spectral response from the vegetation associations; with conifers this may be largely due to the changes that take place in the reflection of vegetation substrata and ground cover. Another easy application is monitoring the freezing of water bodies and river systems. Even in mid-winter, parts of northern rivers (eg the Churchill River) and northern lakes (eg South Indian Lake) show open water leads. These may have significance from the wildlife point of view, and certainly do for fish considerations.

Changes that occur on the surface of the earth can be monitored from satellite gross way — eg natural phenomena such as forest fires (frequency of occurrence, areas burned, habitat destroyed), regeneration in disturbance areas, fluctuations in surface moisture (saturation of wetlands, flooding, etc.) and changes in waterbodies (freezing, thawing, fluctuation in water levels and size, turbidity, and suspended sediments). Such information should be very valuable in approximating the dynamic aspects of the ecological building blocks.

Monitoring of man-caused changes could add significantly to sensitivity ratings of 'Land types' to such changes. Satellite has shown examples of SO_2 damage, shoreline erosion and increased turbidity as a result of artificially higher water levels in lakes, the effect of logging activities on waterbodies, road construction and drainage, dredge spills, urban expansion, and other land use changes.

A combination of NOAA and LANDSAT satellite monitoring is specially attractive for fast change high contrast phenomena such as snowmelt, ice reconnaissance, and surface temperature patterns. The daily coverage by NOAA complements the less frequent, high-resolution LANDSAT. The NOAA imagery may also be of much value for defining the biophysical land regions. These regions are defined by a distinctive regional climate as expressed by vegetation. The temperature information and the extremely small scale of this satellite may add regional climatic parameters.

LAND/WATER INTERFACE

The synoptic view from satellite has clearly shown the relationships between physiography of the 'land' area and water signatures. A very strong relation is apparent between lake and shoreline shape, water reflectance (in the green and red bands) and the surrounding land areas. This relationship is often so strong that water information can be used to infer parent materials and shoreline conditions from turbidity information and lake shapes. In fact, based only on lakes (providing a fairly large number occur in a map sheet), a general physiographic map can be drawn for many areas. Landscape units or even land systems that are uniform as to physiography could often be subdivided based on spectral reflectance of water.

The more sensitive areas of South Indian Lake in Manitoba can be readily identified from satellite, and this is not merely a confirmation of what was known, but a significant addition to the data base which, without the satellite, would have gone unnoticed.

Regional limnology and regional lake surveys can especially benefit from satellite. The satellite will also enable future survey teams to integrate land and water classifications as they will integrate wetland and upland systems.

LAND CLASSIFICATION

As previously mentioned, the LANDSAT scale and resolution are suitable for reconnaissance type of surveys. Work with LANDSAT in Northern Manitoba showed that satellite can be a very effective mapping tool, especially for arctic and sub-arctic areas. Most land systems at a

1:250,000 scale (even at a 1:125,000 scale) can be readily drawn from satellite images. This is also the case for large (organic) wetland areas in the boreal zone. Vegetation in both cases is a good indication of ecosystems, as relatively few disturbances (fires) that distract from these have occurred. In the boreal zone, with its forest cover, broken precambrian physiography (in Manitoba, that is) and its complex fire history, mapping from LANDSAT cannot be as easily achieved. Land systems delineation by means of visual techniques is more complicated and the results are less accurate. Combinations of winter and summer images must usually be used to increase accuracy. No significant work with automated classification has been done yet. It is too early to say that these could improve classification considerably. The land/water relations discussed before were conspicuous in parts of the boreal zone and could be successfully used as a source for land/water delineation. Satellite can recognize significant changes in the distribution of parent materials, when these are expressed by vegetation. Land systems that may differ by less than 20% in the distribution of surface materials may be difficult to separate from a satellite image in the strongly broken precambrian areas.

While satellite imagery can assist im mapping of significantly different land systems, the description of the land systems will have to be based on a description of the land types (ecosystems). For the analysis and description of these 'building blocks', airphoto interpretation is essential and cannot be replaced (airborne sensing could be used to provide additional data).

HUMAN VERSUS AUTOMATED INTERPRETATION TECHNIQUES

Human interpretation techniques are superior for the analysis of airborne as well as satellite Remote Sensing Data for biophysical land classification. Automated interpretation is still in its childhood, and is not expected to produce methodology that will eliminate a human interface within the next five years. However, computer compatible tapes from satellite store considerably more information than black-and-white or colour images produced from them. For instance, the 64 'density levels' of the tape can only be translated into 10-12 grey tones on a black-and-white hardcopy or transparency for the same band. Effective use of all this information will require a computer at some stage. In addition to 'signature' however, shape is critical for delineation and identification. Thus, much of this disadvantage is compensated for as there are no automated techniques yet that can adequately analyse shape. Again, *in relatively simple areas* such as the Hudson Bay lowlands, *automated classification can be very successful.*

Human interpretation can be aided by special enhancement type of equipment such as a colour additive viewer, colour density slicers, or even simple diazo and agfacontour slicing techniques. While these instruments and techniques have their place, their value should not be overemphasized. Some of them (colour additive viewer, agfacontour and diazo) allow temporal overlays of satellite imagery that can be attractive for time-change studies.

In summary, I feel that human interpretation of aerial photographs will always form the most essential component of rapid biophysical surveys.

Cost Considerations

The Airborne Remote Sensing Unit of the Canada Centre presently provides multiband sensing for experimental and development projects on a subsidized price. For 1974, the charge was about $3.40 per sensor line km; there will also be charges for development of film, printing, etc. On a commerical basis, the price would be closer to the $25.00 per sensor line km, depending on sensor package, location, size of area, etc. In an operational project, this would mean about $20.00 for a high-altitude super-wide angle coverage, including some lower level flights for an area of 1,800 km^2.

All of northern Canada is presently covered by black and white 1:63,000 scale photography. Although reflying complete mapsheets is financially unattractive, it would be very effective to fly selected parts (selected by means of satellite) with airborne remote sensing, possibly on a repetitive basis. This would reduce the cost by at least 75%. The combination of satellite, old black-and-white, small scale photography, and recent airborne multiband remote sensing is an attractive low-cost package. The charges for satellite imagery are minimal.

Most of the costs involved in a northern survey are for fieldwork and mapping purposes, and it is therefore unlikely that the use of satellite and airborne remote sensing will reduce cost by more than 25%, if at all. However, the end result, the description and approximation of ecosystems could be significantly improved.

The Manitoba pilot project indicatd that an

acceptable mapping can be produced for about $43,000 (Goulden and Thie, 1970).

The use of satellite remote sensing in combination with selective airborne sensing could be quite powerful if somewhat different approaches are taken. A rapid general type of mapping, using LANDSAT, selected airphoto interpretation and selected field work as main tools, could likely be completed for about $10,000-20,000 per mapsheet. A more detailed regular type of biophysical mapping in areas of high priority could require the regular $40,000 or more if desired in special circumstances (impact studies, etc.) Taking Manitoba as an example, for about $500,000, an area of about 420,000 km^2 could be surveyed in about 3-4 years time.

AN OPERATIONAL SYSTEM

Satellite imagery can provide a basic operational tool for a rapid resource survey in combination with existing black-and-white photography and supported by selected airborne sensing. Based on experiences with satellite data, the following procedure is suggested:

1) The formation of a team composed of one ecologist, one pedologist-geomorphologist and one limnologist. The ecologist should have a wildlife background, otherwise a wildlife biologist may have to be added to the team.
2) Existing satellite data should be used to delineate (preliminary) land districts and broad land systems (1:250,000 scale). Repetitive imagery and enhancement techniques should be used.
3) Based on satellite, areas should be selected for airborne sensing, photo interpretation and field work.
4) Based on fieldwork selected areas (land types) should be described. Based on temporal satellite data, dynamic phenomena should be included.
5) Results extrapolated using satellite where possible.
6) Final maps to be prepared on LANDSAT mosaics.
7) Total cost about $10,000-20,000 per 12,800 km^2.
8) A detailed survey can be carried out simultaneously in high priority areas. This survey will have to be mainly based on airphoto interpretation. LANDSAT's role is strongly reduced (relatively speaking).
9) Continuous updating of conditions using LANDSAT, as well as monitoring effect of management and planning decisions.

Points 1-6 could be completed in a period of 3-4 years; 8 would require significantly more time (10-20 years), while 9 would be done continuously in areas of rapid change.

REFERENCES

Goulden, R.C. and J. Thie. 1970. Land classification in Northern Manitoba — a proposal. Resources Planning Branch, Department of Mines, Resources and Environmental Management, Winnipeg.

MacDowall, J. and P.A. Lapp. 1973. Sensor development: An overview of recent Canadian experience. American Astronautical Society, Publications Office, P.O. Box 746, Tarnana, California.

Subcommittee on Biophysical Land Classification. 1969. Guidelines for bio-physical land classification (comp. by D. Lacate). Queen's Printer, Ottawa, Cat. No. FO77-1264. 61p.

Tarnocai, C. and J. Thie. 1974. Remote sensing and permafrost. Technical paper, Canada Centre for Remote Sensing, presented at Workshop of Permafrost Hydrology and Geophysics, February 1974, Calgary.

Thie, J. 1972. Application of remote sensing techniques for description and mapping of forest ecosystems. Paper, 1st Canadian Symposium on Remote Sensing, 1972, Ottawa.

Zoltai, S.C., C. Tarnocai, and E.G. Oswald. 1969. Land classification for land evaluation, Cormorant Lake Pilot Project. Canada Forest Research laboratory, Winnipeg. Information Report MS-X-20

DISCUSSION ON THE PRESENTATION

G. Beanlands inquired about the potential for LANDSAT in climatic mapping. *Thie* felt that there were severe limitations. With NOAA (weather satellite) and LANDSAT he felt that there were some possibilities for use. He indicated that he had done no work on weather or climate studies. *G. McKay* felt that there was some potential for use of LANDSAT in this regard. He indicated that NOAA has been used in this respect, and there is also potential in this area for high resolution satellites.

PHYSICAL RESOURCE DATA NEEDS IN LAND USE PLANNING

G.G. Runka
B.C. Land Commission
Burnaby, British Columbia

Physical resource data and inventory should *be an important input into the formulation of goals and objectives, the preparation of planning standards, the analysis of existing land use, plan synthesis, test, and evaluation, and perhaps most important of all, plan implementation.* Most people would probably agree with this motherhood statement. I would now like to follow this up with a quote from a book called "Northern Realities":

> *Two myths still persist about the north. To some Canadians it is a harsh, barren land inhabited by smiling Eskimos, staunch Mounties and mad trappers. To others it is a rich storehouse of wealth, just waiting to be opened up and settled. The report commissioned from Acres Research and Planning Limited by Richard Rohmer, of the Mid-Canada Development Foundation, contrasted the two myths and came down firmly on the side of the rich storehouse:*
>
> > *Usually it (the area lying north of the settled belt of Canada) is thought of as a frigid, barren wasteland with fantastic problems of climate, lengthy periods of darkness and permitting only semi-permanent life . . . . It is a vast undeveloped but most important area with the potential to support millions of people. The advent of new and easier forms of transportation, better and cheaper communications, a possible open Arctic route, new port development on the Arctic, Pacific and Atlantic oceans, new forms of environmentally controlled town development, more amenities and incentives will create an unlimited potential for the extension and the location of economic activity and settlement in Canada North.*

Prose similar to this has frequently appeared in the literature in recent years. The north is neither a cold desert, nor a rich storehouse. Rather, it is an enigma, and the two extreme conceptions conceal the immense complexity and variety of the north.

If we are to *effectively* plan for use of our northland, we must do so within the ecological constraints that present themselves, and to do this we *must* have physical resource data. Nature is a process; it interacts, it responds to laws that represent values and opportunities for human use, and it has certain limitations and even prohibitions to certain of these uses. The requirements and necessity for physical base data as a tool for any sort of resource planning are not very obvious to the public or their representatives, the politicians. Planning has gone on and will continue to go on without physical resource data; poor decisions are the result. The Peace River Dam project in North-East British Columbia is one example. Because of the lack of physical resource data, we did not foresee the very negative lesson nature has repeatedly tried to teach us: we must look beyond specific projects or resource development to the effects upon the land as an ecological whole. This is not always easy to do, and there are some very real problems to contend with:

1) Time. We usually start collecting data *after* the planning decisions have been made. Somehow demand is not high enough to warrant expense until the eleventh hour. All too often data is collected in a rush, and perhaps inaccurately mapped; as a result, the credibility of the whole process is open to question by the user. Or, conversely, the data is diligently collected, two years after the planning decision has been made; by this time, the project is often too far advanced to make really effective use of the data collected.
2) Many planners are not used to having physical or ecological surveys for a wide range of uses. Through training and/or experience they are more familiar with the zoning concept, which enforces segregation of land uses. The recognition that certain areas are intrinsically suitable for several land uses can be viewed either as a source of conflict or as an opportunity to use these areas in a way that is socially desirable. Most land use maps, and even planning proposals, show over-generalized categories

of use. Because of scale or perhaps because of the accustomed dreary consistency of zoning, the great complexities are reduced to absurdities. We are not used to perceiving the real variables in the environment and responding to these in our plans.

3) Although base surveys are essential, their integrated complexity makes them difficult to present or to educate with. How do you put across to a politician the significance of the various clay minerals in the Bt horizon of a soil, even though the characteristics of these clay minerals may be most significant from an engineering cost viewpoint?

4) Even in this day and age some of the stumbling blocks to using survey data are financial and technical. Everyone wants to use data, but few desire to collect it or map it, and more particularly, pay for collecting it or mapping it. The scale at which this data is presented is particularly important. Flexibility in mapping scale and type of information data collected is essential for different levels of planning.

By way of history, in 1963 the most modern map of the Yukon Territory contained at least a dozen errors; some of them were serious geographic mistakes, but it replaced a map that contained a large blank spot in the northern part of the territory. We are just now exploring the needs for and uses of survey data for by far the largest part of Canada and for every planning need imaginable.

The following lists some of the specific biophysical data requirements necessary for ecological land use planning. Keep in mind that planning should ideally be a process through which all options (physical, biological, social and economic) are integrated.

Land Use	Some Physical Resource Data Needs
Mining	Bedrock -ecological damage Surficial geology hazard emphasis Pedology -large scale in Climate production areas Vegetation -large to small scale in exploration areas
Petroleum	as above
Wildlife	Vegetation (Habitat) Animal (Pop. Dynamics etc.) Pedology - Surficial Geology Climate
Fisheries	Water (Limnology) Pedology Surficial geology
Recreation	Shoreland features & water characteristics Climate Surficial geology Vegetation
Community Location & Related Watersheds	Surficial geology Climate Vegetation
Transportation & Utilities	Surficial geology Pedology Vegetation
Forestry	Vegetation Climate Pedology Surficial geology
Agriculture	Climate Pedology

The essential precondition for planning — the formulation of common sense choices — is to know the environment. Because of the slow recovery rates of the major environmental components, ecological damage hazards would have to be a key planning consideration in the North. Climate and surficial geology should also rate high in any consideration of data requirements for land use planning. Above all, we must recognize the complexity of the Northern environment, and education in the use of physical resource data cannot be over-emphasized. Remembering that political and economic processes carry on, we must set our goals and objectives within this framework.

DISCUSSION ON THE PRESENTATION

M. McKay asked about Runka's experience involving local people in land use planning. *Runka* indicated that as far as using Canada Land Inventory data, the people accepted the information. When detailed areas were looked at, however, problems arose. There was also a problem with the accuracy of mapping. He felt that basically it had been successful.

HUMAN AND PHYSICAL DATA NEEDS IN LAND USE PLANNING

R.D. Thomasson
Manitoba Department of Mines, Resources and Environmental Management
Winnipeg, Manitoba

INTRODUCTION

Land use plans for Crown land in Manitoba are developed to allocate land to uses and to integrate uses within land areas so that the goods and services required by people for a high quality life can be provided. The data needed for plan development falls either into the human category or into the physical category. Physical data is largely static, whereas human data is dynamic.

The planning process consists of three basic steps: 1) the gathering and assessment of human data to determine demands; 2) the gathering and assessment of physical data to determine land capability for various uses; and 3) the matching of demands to the land to produce the goods and services required, to ensure maintenance of environmental quality, to facilitate efficient production of goods and services, and to minimize land use conflicts.

Planners have approached planning problems by working from the specific to the general, from the general to the specific, and from the middle to both ends. Working from the general to the specific assures that the developmental direction set for each planning area as a whole is carried through the sub-areas. For this reason, it is generally accepted as the preferred approach. Since it is desirable for planning to move from the general to the specific, it is reasonable to suggest that data collection also move from the general to the specific with detailed data gathered only where detailed planning is contemplated. In all cases, survey data levels must be appropriate to the planning level, not vice-versa.

HUMAN DATA

Data about humans has its greatest use in establishing demands for goods and services (eg recreation, jobs, food, cottages, etc.). It is dynamic and generally unmappable, and any survey associated with human data must therefore be a continuing program.

Basic data is demographic and includes age, sex, birth rate, death rate, education levels, employment skills, employment levels and employment participation rates. This data permits a quantified assessment of the need for jobs, labour balance studies, estimates of future work forces and populations. Zones of influence and activity must also be considered basic but are, of course, mappable.

A second order of human data pertains to health, housing, nutrition, water quality and the human environment in general. This data, through area comparisons, identifies areas of sub-standard living conditions where social programs must be considered in plan development. Some indication of the size of the needed social programs can also be gained during the comparison process.

A third order of human data is of a psychological nature and involves an evaluation and interpretation of the plan clients' value systems and expectations. Some aspects, such as recreation participation, can and should be quantified. Other aspects cannot be quantified. These often seem somewhat illogical and relate to feelings of security, social orientation, social association, status and self-worth. They result, for example, in requests for new roads so that relocated communities can continue to relate to a traditional service centre instead of adjusting to a new one <u>and</u> in the manifestation of vicarious needs (eg the demand for wilderness by people who do not intend to visit or use it). Satisfaction of these psychological-type needs seems to depend more upon the political clout of the groups expressing the need than upon any other criteria. The result is that many needs are unrecognized and therefore remain unsatisfied.

Data directly related to humans is in a continual state of flux and must be monitored on a continuing basis. How much data should be collected by a survey group and how much by planners is an open question. Survey can save the planner much time by collecting data, but the planner must get to know his clients and

client groups if he is to have maximum effectiveness. One way of ensuring that the planner meets his clients is to force him to gather and/or upgrade some of the human data, especially that related to the third order (ie psychological needs).

PHYSICAL DATA

Physical data is generally static and mappable. Exceptions do occur, but the processes of soil formation, climatic change and natural drainage channel development are so slow that, from a man-centred point of view, they can be considered static. Thus, it is possible to consider a once-over type survey at each desired level of detail until new technology renders past work obsolete, at which time the survey should be updated. This necessitates, in essence, some type of continuing survey program.

In terms of what is needed, one must start at the basic and move toward the particular. The basics are physiography, hydrology and climate — the characteristics of land which determine its social and economic value. The environmental consciousness which has recently developed in society suggests that environmental resilience, present land use, and infrastructure are also basic. The latter is dynamic, and the base from which future development will grow.

Basic data alone is not sufficient for an effective planning program. Quantified information relating to land and water capability for the production of goods and services is also needed. This data is most useful, however, if it is divided into its static and dynamic segments. This means removing the influence of present land use upon capability assessment so that capability reflects only the effects of physiography, hydrology and climate and as such is static. The effect of present land use, be it biological or economic, is dynamic. It should be integrated with capability in a separate process, the product of which is a measure of present productivity. To be of greatest use, present productivity must also be quantified.

Information regarding capability and present productivity for all goods and services under consideration for production in a planning area is needed. This can include fisheries, wildlife, agriculture, forestry, recreation, minerals, urban development, cultural features, transportation, recreation supply, etc. All information may not, however, be required in all areas at all times. Therefore, it is necessary for planning and survey personnel to cooperatively design their programs giving consideration to the goal of the planning program and the practicalities of the survey.

GENERAL COMMENTS

If planning is to deal effectively with the changing values and value systems of our society, it must be continuous. Thus, a survey program associated with planning must also be continuous. It must be prepared to gather new data whenever need can be demonstrated. It must quantify as much data as possibe and be flexible so that the level of data-gathering can match the level of planning. Where planning is being done at the general level, data must be available at the general level. Where planning is specific, the survey must be specific if the planner is to have the information he needs when he needs it.

SUMMARY

Human and physical data should be collected in an ongoing program. Basic human data which should be collected includes demography, zones of influence, recreation participation, and measures of the human environment and of health. Data concerning values and value systems must be looked into in more depth before determining if survey or planning personnel should collect it. Basic physical data which should be collected includes physiography, hydrology, climate, environmental resilience, present use, and infrastructure. Quantified capability data will be required for different uses in different areas. Capability should, however, be based on physiography, hydrology and climate, with present use being used to adjust capability to provide a quantified measure of present productivity.

Data should always be collected at a level appropriate to the planning program to which it is an input. As such, there must be flexibility regarding the level of detail collected as well as the type of data collected.

DISCUSSION ON THE PRESENTATION

G. McKay disputed the point that climate could be considered static. *Strang* inquired as to how to involve the people who are going to be affected by the plan. *Thomasson* replied that a thorough planning process may be the only way of defining the demand for goods and services. It is unacceptable to decide what is good for people and thrust it down their throat. The planner must be prepared to submerge his personal preference below those of the people he is planning for. *Duffy* wondered if there was any evidence in Canada of social scientists developing procedures to integrate social and physical data. To-date there has not been much evidence of the social and natural sciences working together.

NORTHERN DEVELOPMENT INITIATIVES

R. Young
Department of Regional Economic Expansion
Ottawa, Ontario

This paper discusses DREE's role regarding the Western Northlands. As concerns the social and economic situation of the residents of the Western Northlands, for most of them — certainly those dependent upon traditional activies — income is inadequate and the amenities of life are very rudimentary. The consequences of this are social pathologies in the form of family breakdown, increased rates of criminality, etc. Whatever remedies of a public nature may be applied to these northlands, their success will depend upon the degree to which there is coordination and balance in the requisite public programming for the broad region. This has led DREE to pursue, with a view to adding a new dimension or concept to public programming in the Western Northlands, discussions with provincial governments, other federal departments, and with representatives of various associations. These discussions have concerned coordination of public programming and the necessity for placing high priority upon the desires and the participation of local people in this programming. Hopefully, these discussions will in the next 12 months formally culminate in sub-agreements between DREE and each of the four western provinces for a more balanced type of public activity relating primarily to each province's northerly areas.

In DREE's view, programs of northern development should embrace three important components:

1) Maximizing the options for local people in the north for participating in the development of their area.
2) Making existing communities better places in which to live (this comes out of recognition that such communities, in spite of their lack of opportunity and their lack of physical and social amenities, have been and likely will be in existence for a long time).
3) Coordinated efforts among provincial agencies, federal departments and local people towards an orderly development and conservation of the resource which are vital to the future economic and social growth of the western northlands.

Pending formalization of arrangements relating to each province's northlands, and in the interest of fairly early action, discussions are underway which should lead to interim arrangements between DREE and the western provinces by which initial coordinated programming can be put into place. Referring to discussions with Manitoba as an example, joint action is shaping up in three broad program areas which undoubtedly will apply elsewhere in varying degrees across the west:

1) Human development and community services - Action is aimed at providing assistance to families and to communities for the enhancement of their social and physical milieu and at encouraging local involvement and participation in community affairs and in developing opportunities (eg ways and means to effect housing improvements, improvement to the physical community, and increasing the options available to local people in respect of employment opportunities). Developments of this kind require close collaboration between provincial authorities and federal agencies such as Canada Manpower, Indian Affairs and CMHC.
2) Need for improved transportation and communications - The major concerns are for the provision of reasonable year-round transportation for goods and services and for methods of communication which consider the linguistic differences which hold in northern areas.
3) Resources and community economic development - This will focus upon the assessment, planning and utilization of resource-based opportunities and upon initiatives in community economic development.

Populations of many remote communities have been mounting steadily with consequent increasing pressures upon available resources. A need in this regard is data which can serve as a basis for planning respecting sound land use and resource allocation. This has potential for a fairly large undertaking, and it is hoped that the suggestions from these proceedings will lead to ideas for the formulation of an integrated approach to base data surveys for

the northlands. It is also hoped that thought will be given to ways and means by which involvement of local people might be accommodated with respect to the planning and data-gathering of resources. While such assets are largely in the public domaine, the people of the northlands do have a kind of proprietary interest in them, and many of them do know the resources of their area.

In its dealings with Indian people, Indian and Northern Affairs have learned that it cannot do things for Indians but rather with Indians. This also holds true for non-Indian residents of this region. This brings me back to the point relating to the concept of programming which DREE is trying to engender — ie coordination at all levels coupled with active participation by local people. The real test activity in the northlands lies in its results vis-a-vis the well-being of the residents, and the success of any programming depends upon a tripartite approach involving the province, other federal departments, and local people. DREE considers that it has accomplished much if, through the flexibility of its northlands sub-agreements with each province, it has aided in the viable growth of this approach.

DISCUSSION ON THE PRESENTATION

The discussion centred around the involvement of local people in the planning process. *Seifried* raised the question regarding the role of the three levels of government in northern development initiatives. In answer to a request from the moderator, *M. McKay* outlined Manitoba's approach to northern development. He expressed the hope that as a result of consultation with northern communities, an approach will be developed. *Roberts* explained that in Saskatchewan their approach is similar to Manitoba's in that they are trying to foster local government organizations.

G. Young illustrated the problem of getting information to the people and getting responses by outlining his experience in the Okanagan basin study. In that area, a public involvement consultant was employed and they used the 'interest based task force approach'. The final task force was comprised of technical and lay people, and a very good public input was provided for the technical report. In this case, the local people had a very strong input into the water management of that region.

On a different note, *Brack* inquired as to whether DREE had initiated any discussion with the Department of Indian Affairs and Northern Development to achieve integration North of 60° and South of 60°. *Young* replied that discussions were taking place but he was unsure of the extent of these discussions.

SURVEYING FOR ENVIRONMENTAL MANAGEMENT[1]

J.S. Rowe
Department of Plant Ecology
University of Saskatchewan
Saskatoon, Saskatchewan

What is this 'environment' that is to be managed? It is the *geographic space* at the earth's surface, the land-and-water "landscape units" or 'terrain units' that make up the biosphere. As one organism among many, man lives *in* the landscape — dependent on it and using it, hopefully without destroying its life-supporting properties. The landscape environment is an adjusted system whose parts are complexly interrelated. Environmental managers aim to safeguard the parts and relationships that are critical to the continued functioning and renewal of the biosphere.

Unfortunately, most educated people have been trained in disciplines or special fields, making it difficult for them to conceptualize and understand 'environment'. Scientific knowledge, it has been assumed, advances by specialization — by reduction, by analysis of systems into subsystems so that understanding (in universities and governments) has been departmentalized. We are specialists in geology, hydrology, wildlife, soils, recreation, vegetation, climate, urban affairs and human resources. Like the blind men in the fable trying to conceptualize the elephant, each operates on the basis of his narrow, disciplinary, anatomical knowledge. *How do we get it all together to see the interconnected world as it really is?*

Below are the anatomical disciplines, each having a part of the living landscape (the elephant in the fable). *Is there any way to integrate their knowledge in an acceptable, logical way? What about asking the social science to do the job, to provide the glue that sticks it all together?* After all, it can be argued that we do all our work in the interests of the human race; and man is the measure of all things. Identify the human needs, get straight on what in environment is important to man, and forget the rest. By this route we simply come to a resource inventory (resources being what we can convert to our own ends) and the conventional outlook that we have traditionally had. There is no help here in seeing the world whole. The only way to that goal is to put man in perspective as a biological component, a heterotroph within the larger landscape system.

I would like to stress the very great dangers to 'earth care' if we continue the species selfishness that has characterized the human race in the past. The highest ethic of our religion has been altruism, looking after other members of *Homo sapiens!* There is no help for environment and the biosphere in

[1] A paper prepared for but not presented at the workshop

that man-centered approach. Recreational land use planning illustrates the point. It has argued that parks should be placed near where people are — ie large park areas should be procured in the vicinity of cities, because "parks are for people". Well and good so long as the corollary is not accepted that remote wilderness areas, where few can ever hope to visit, are worthless and dispensible. Such areas are valuable for the preservation of the biosphere, and only indirectly for the preservation of the human race. Such parks are *not* for people and should be valued for that very reason.

If we agree that man should fit himself to the world, at least to some extent, rather than continuing on the path of domination of nature, thereby knocking bigger and bigger holes in the biosphere, then another basis for "seeing the world whole" must be sought. We return, in fact, to the natural landscape, the natural units of terrain.

I began by stating that the landscape environment is a whole, and that we have broken it into separate parts. Furthermore there is a natural tendency for each one of us to hold that *our part is the essential environment* or at least the more important part of it. It is hard for a professional to accept that his field is no more important than many others, and that his bit of knowledge may be peripheral to the core. It may not be palatable either, but it is demonstrably true, that fragmented disciplinary knowledge unintegrated into the larger world picture is potentially dangerous to the environment. If, for example, the experts know all about rivers but little about the watersheds they drain, then there is a likelihood that their knowledge will be used in ways that damage the watersheds. So the reason for attempting to conceptualize and understand environmental wholes is clear — it is the only realistic basis for environmental management, and any lesser approach simply asks for trouble.

How can it be done? Surprisingly little brain power has been applied to answering this question. Educated and competent in our narrow fields, we find the question baffling. The approach traditionally proposed is what is called "multidisciplinary research", whereby all the resource sector specialists are assembled and each is told to go forth and do his own thing. Often each disciplinary team writes its own terms of reference with a fine disregard for what other teams are doing. There is little or no cooperative planning or field work. A rosy optimism prevails that somewhere sometime a genius Study Director or Coordinating Group will fit it all together and, from the bins full of odd parts, a functional organic whole will take shape. This is the Mackenzie Valley Syndrome and it shows a touching faith in miracles and the power of prayer.

Let's stop fooling ourselves. The approach is *wrong* and no miracles are going to happen. If the people that do the work and collect the data are not together, mentally and physically, the results are bound to be confusing at best, chaotic at worst. There must first be a common concept of environment to which all knowledge, all studies are related. This means firstly that each cooperator must be prepared to see his field in relation to the larger, more important whole that provides the basis for 'interdisciplinary', 'trans-disciplinary' or "supra-disciplinary" studies. Secondly, the conceptualizing of the environmental whole and the relating of parts to it must be a continuing, cooperative endeavour that brings people together in workshops and in the field. It is an essential part, perhaps *the* essential part, of the whole exercise.

The idea is clarified by reference to the environment as one large integrated system (the biosphere) composed of sub-systems (eg continents and seas), sub-sub-systems (eg geographic regions), etc. down as far as one wants to go. Now the study of sub-systems (by special fields or disciplines) is given meaning by the larger systems that comprise them. We study the anatomy and physiology of an organism, for example, to understand how it works, but it is the concept of the whole organism that gives meaning and direction to the anatomical and physiological studies. There must be agreement on what the significant systems are, at various levels of integration, before the relevant anatomical and functional studies can be identified.

The argument leads to the following conclusions regarding an integrated approach to studies and data collection for environmental management:

1) Environment must be conceptualized as a hierarchy of geographic functional wholes or systems including man, from the biosphere to the region and so on down to the smallest area of significance.
2) Each geographic level — region, district, site, etc. — is an integrated whole whose parts are in some state of adjustment. The purpose of study is to understand the geographic systems and subsystems in terms of the adjustment of their parts to one another.
3) To collect the relevant data in an integrated way, the cooperators must agree on basic concepts and approaches. They

must recognize the same systems and subsystems, from the largest to the smallest, and agree on what anatomical and functional features are important. In the north the functional aspects that are central to all systems and all studies may, for example, be stream flow, permafrost degradation, erosion and biological production.

4) Cooperators (both social and natural sciences) must work together in conceptualizing environmental units, their significant parts and their functional relationships. The desired integration of knowledge can only come as an evolutionary process, and unless provision for this evolution of understanding is built into the entire plan, the results will be the same as in the Mackenzie Valley — a plethora of disconnected bits of information, without a conceptual framework, to give them meaning.

5) Given a comprehensive conceptual approach that accepts the wholeness of environment and the hierarchical relationships of its parts, base line data collection can be directed in a meaningful way. Without such a framework, data collection will be of dubious value.

CONSOLIDATION OF IDENTIFIED BASE DATA REQUIREMENTS FOR VARIOUS SCALES AND LEVELS OF SURVEY INTENSITY

EXPLANATORY NOTE

For the afternoon session of 17 April 1974, Workshop participants were separated into seven study groups to identify what data needs are required by discipline and at what level of intensity. Six groups dealt with biophysical data needs, while the seventh group investigated the needs for socio eco-onomic data. The groups dealing with bio-physical data needs considered the following topics:

1) Geology (bedrock and surficial)
2) Soils
3) Vegetation
4) Climate
5) Water
6) Renewable Resources including agriculture, forestry, fisheries, recreation and wildlife
7) Present Resource use and Archaeology
8) Photography and mapping requirements for the above seven topics.

The socioeconomic study group considered only social and economic information needs. This part of the Workshop aimed to investigate, by discipline, those parameters which are both required and feasible, at and from different levels (scales) of survey intensity. An attempt was made to have the composition of each study group structured so as to provide a cross section of specialists and disciplines.

For each subject area, the study groups were requested to consider:

1) The prerequisite kinds of information such as aerial photographs and base maps that are necessary to enable the implementation of surveys at various scales.
2) The types of information (parameters) that should be collected by each discipline, the form in which the resulting information is required (ie primary or processed data), and the manner in which the final output should be presented (ie maps, tables, legends and reports).
3) Phasing requirements (ie the lead time or need for supporting information from other disciplines to be collated in order to carry out certain types of surveys).

The following pages provide a summary of results from the study group sessions. No attempt has been made at this stage to identify individual government agencies in regard to their responsibilities for carrying out survey programs. This summary should be considered in light of the following overriding assumptions:

1) There will a followup to identify the prime potential users of base line data so that the kind of environmental parameters and the format by which they should be documented can be refined.
2) In the identification of future data needs for Canada's Northlands, previously collected base line information, where available and applicable, will be collated and incorporated into future survey programs.
3) Recognition must be given to the potential use of computers for data storage, analyses and presentation.
4) A hierarchical survey system is required to provide information at various levels of detail.

Basically, three hierarchical levels (scales) of information detail were identified:

1) 'Broad Brush' surveys - Base information at a highly generalized level (1:500,000-1:1,000,000). There is a need for an overview for extensive areas of northern Canada over the next five years. Little time was spent investigating possible surveys at this scale since the consensus of the study groups was that information at scales of 1:125,000-1:250,000 would constitute the basis or working level for future survey programs.
2) Reconnaissance Surveys - Information at a reconnaissance level of detail (1:125,000-1:250,000) would provide basic information from which provinces and territories would carry out regional land use planning and resource allocation studies and programs. Such surveys, while still cursory, must be comprehensive and integrated and must be undertaken by multidisciplinary teams.
3) Detailed or Site-Specific Information - Detailed investigations (1:10,000-1:60,000 or larger) will be required for purposes such as the mile-by-mile assessment of a pipeline, the identification of site-specific areas for processing plants, urban developments, or the management of specific areas of land.

CONSOLIDATION OF BIOPHYSICAL DATA NEEDS

BIOPHYSICAL DATA NEEDS — PRIME ENVIRONMENTAL COMPONENT

Sector: Surficial Geology

Prerequisite Information		Required Sector Data		Phasing Requirements and Comments
Type	Scale and Coverage	Order and Scale	Format	
Topographic maps LANDSAT imagery, high altitude photography	1:1,000,000-1:500,000	Maps at these scales would provide broad regional physiographic subdivisions. Surficial geology maps at these scales (1:1,000,000-1:500,000) should provide information on surface drainage, relief, morphology, origin of materials, lithology, depth and dynamic aspects (processes).	NTS base and data matrix or extended legend. Presentation of derived information.	Such surveys should incorporate any existing information. Requirement for integration of sector inputs into mapping techniques & legends. - lead time required for planning - generalized maps to provide overview only.
Topographic maps	1:250,000-1:125,000 (In the future, 1:100,000 metric may replace 1:125,000). All maps should be of latest series. Controlled mosaics, if available; scale 1:60,000. Conventional Photography - B&W at 1:50,000, preferably flown in fall. LANDSAT - colour and colour infrared, sequential coverage to show change over time. Complete airphoto coverage required.	Scales of 1:250,000-1:125,000 considered as working level. In addition to base data identified for scales of 1:1,000,000-1:500,000 (see above), require information on texture, thermal regime, ground ice, identification of granular and borrow and road base materials, slopes, spatial relief, stratigraphy, geomorphic history.	NTS base maps with extended legends, reports, derived user maps as required such as granular material, trafficability, availability map, etc.	Same comments as above. Lead time required to incorporate and integrate existing information and supportive research studies. Surficial Geology map document at 1:125,000 will serve as basis for interpretations on forestry, wildlife, fisheries, recreation, engineering & mining.

Sector: Surficial Geology (continued)

Prerequisite Information		Required Sector Data		Phasing Requirements and Comments
Type	Scale and Coverage	Order and Scale	Format	
Topographic maps	1:50,000 or larger. For designated areas to be mapped at the large scales require supporting mapped data such as bedrock, soils; maps should be of latest series & complete for designated study areas.	Same base data as identified above.	Same as identified above.	Surficial geology map document basic to all other required resource information (see above).
Remote sensing	B&W, Infrared 1:30,000-1:50,000 complete coverage for area under investigation. LANDSAT imagery as needed.			
Orthophoto mapping	Orthophoto mapping (eg 1:2,400) required for site-specific planning & development.			

Sector: Bedrock Geology

Topographic maps	Same requirements as for surficial geology. Topographic map base at 1:1,000,000 for overview; 1:250,000 as working scale.	Working scale for mapping 1:250,000-1:500,000. - materials - lithology	Map & Report	Basic: can be obtained independent of other studies.
Imagery	Black and white photos (1:30,000-1:50,000). LANDSAT imagery useful for overview.			

Sector: Soils

Bedrock geology Surficial geology	1:500,000	1:500,000 soils map could be prepared on basis of existing base information collected for surficial geology etc., and as a generalization of soils information collected at scales of 1:250,000-1:125,000.	Soils information could form part of surficial geology map; extended legend.	

Sector: Soils (continued)

Prerequisite Information		Required Sector Data		Phasing Requirements and Comments
Type	Scale and Coverage	Order and Scale	Format	
Topographic maps	1:250,000-1:125,000; contour intervals important.	Working level for soil survey preferably 1:125,000.	NTS base map, line maps, photo mosaics, enlarged photos, extended legend, soil description & accompanying report. Standard data forms (CANSIS).	Geology maps; geomorphological history, broad general vegetation information; where applicable, ground ice and frozen soil.
Remote sensing	Same as for surficial geology.	In special cases, may use 1:250,000. Working level should provide information on soil to depth of 6 feet — texture, surface & profile, external & internal drainage, depth of soil to bedrock or ground ice.		Research into resource interpretation.
Photo mosaics	Working scale of 1:125,000. Photo scales should not be more than 2x the working scale.		Derived information as required such as erosion hazard, trafficability, productivity for agriculture, engineering properties, etc.	Soil maps at 1:250,000 scale not useful for management purpose.
Base data	Prerequisite information on geology, geomorphology, surficial drainage, present land use, climatic data, and vegetation. Information should be at compatible scales.	Micro relief, vegetation, processes, active layer, ice content, and soil classification.		
		Statement to indicate measure of reliability and percent composition of the mapping units.		
	1:50,000 or larger. Same required as provided for surficial geology.	Special projects at scales 1:50,000 or larger.	1:50,000 line map or photo base map.	
	For 1:50,000 scale must have 1:50,000 base maps, photos or airphoto mosaics.	Same parameters as listed above. For urban purposes, recreation, or engineering require soil stability etc. at a scale of 1:10,000-1:50,000. Types of observations and analysis required are dependent upon specific use or need.		

Sector: Vegetation

Topographic maps	Scales 1:250,000-1:125,000. Same requirements as for geology and soils.	Working scale 1:250,000-1:125,000. Require information on plant associations, species lists, species	Base map, and extended legend (description giving species list & succession). Report & derived	Survey program would utilize: 1. Available geology and soils information

Sector: Vegetation (continued)

Prerequisite Information		Required Sector Data		Phasing Requirements and Comments
Type	Scale and Coverage	Order and Scale	Format	
Imagery	Season more important than in geology and soils; at least summer imagery. Sequential may be as important as seasonal. Black and white, colour & infra-red. Scales 1:30,000-1:40,000. Require prerequisite engineering & forestry information collected from all ongoing programs. Past land use and historical perspective for land disturbances.	communities, productivity measurements (eg biomass), wildlife habitat & food. Present vegetation status, plant succession, identification of unique features or areas.	maps as required. Descriptions should be tied into representative terrain units. Derived information as required on capability & sectorial requirements such as riparian & submergent vegetation, climax vegetation & vegetation diversity.	2. Information on habitat and dynamics (ie succession). 3. Present land use. 4. Terrain disturbance, historical aspects. 5. Vegetation anomalies, floristic parameters. 6. Supporting wildlife information (ie species distribution). 7. Utilization of forest inventory data where available from federal and provincial agencies.
Forest inventory maps	1:13,200-1:16,000. Map & photos must be recent and updated.	Special projects at scales larger than 1:50,000.	Maps & reports as required.	
Topographic map				
Airphotos				

Sector: Climate

Topographic maps	Coverage at 1:1,000,000 minimum requirement. 1:250,000 required for special studies.	1:1,000,000 for overview. For special projects, information should be at 1:250,000 or greater.	NTS series at 1:500,000. Greater presentation of detail for urban and rural problems as required.	Require supporting data on freeze-up and break-up, location of late-lying snow banks.
Network	More long term stations required for primary climatic data, including soil temperatures. Ground stations to be located at meaningful locations.	Isolines of growing days (frost free days), temperature or other ecological parameters.	Presentation of: 1. normal data breakdown 2. Statistical reliability 3. Special interpretative or derived maps as required (erosion hazard, etc.).	Present data inadequate to define zones or regions; meaningless from ecological viewpoint.

Sector: Climate (continued)

Prerequisite Information		Required Sector Data		Phasing Requirements and Comments
Type	Scale and Coverage	Order and Scale	Format	
Vegetation Geology ERTS NOAA Imagery Review	Require data on vegetation & permafrost — perhaps exploration companies who drill could provide supporting information. 1:500,000-1:250,000. Imagery at 1:50,000 required for special projects. Need to review global considerations derived from surface information. Accurate record of historical events (floods, droughts etc.). Need for the proper interpretation of records.	Precipitation, rainstorms, snow depth, precipitation on a yearly basis, evapotranspiration. Prevailing winds, thunderstorms, lightning strike zones. Local climate.		Need more information on snow as it relates to wildlife, vegetation, etc. 15-year lead time required for planning and collection of data.

Sector: Water

Type	Scale and Coverage	Order and Scale	Format	Phasing Requirements and Comments
Geology, soils, vegetation and climate Land use Hydrological survey data Drainage basin maps Special Projects - scales and data as required.	Working scale 1:250,000-1:125,000. Present land use and a mechanism for updating land use is essential.	For working scales of 1:250,000-1:125,000, information should be provided for all main flowing streams, tributaries and draining lakes. Primary information should include: - discharge hydrographs. - upstream storage capacity, water quality (chemistry and sediment). - incidence of springs, currents - maximum flow, significant currents, water volumes & fluctuations. - carrying capacity for debris - nutrients for fish (ie physical, chemical and biological properties of water — biological productivity). - distribution of outlets, obstacles, shoals, shoreline characteristics, bathymetry.	Charts, tables, maps in certain cases. These maps should be tied to surficial geology maps, etc. extended legend and report. Derived user maps as required on such aspects as flood hazard, effect of dams and diversions, storage & hydro power potential, use of waterway as transport corridors (both commerical and recreation), water use and water supply, evaporation of free standing surfaces.	To generate outlined data requires lead time of 10 years to build up data on water quality and water quantity; need supportive research and data on freeze-up and break-up, fresh/salt water interface (bathymetric, ecological studies of estuaries, etc.). Discharge/recharge areas. Need for integration of disciplines in biology, limnology, & marine sciences. "Water maps" should give statistical basis for reliability or probability of presented data.

BIOPHYSICAL DATA NEEDS — RENEWABLE RESOURCES (PRIMARY AND DERIVED DATA) AND ARCHAEOLOGY

Sector: Agriculture

Prerequisite Information		Required Sector Data		Phasing Requirements and Comments
Type	Scale and Coverage	Order and Scale	Format	
Surficial geology Soils Climate Vegetation Water	Biophysical data needs (scales and coverage) identified on preceding pages.	- Agriculture soil capability. - Growing season (frost-free period). - Agriculture markets, economics and management. - Incidences of uncontrollable pests.	Maps and report.	Must know what the regeneration capacity of the land is.

Sector: Archaeology

	Base line data (surficial geology etc.) of value in initial identification of probable sites.	Historic & prehistoric sites.		- To minimize pilfering, avoid mapping individual sites. - Report all finds to proper authorities. - Ensure that field personnel working in northern areas are aware of importance of archaeological sites. - Involvement of local people would assist in identifying sites.

Sector: Fisheries

Surficial geology Water Climate	Biophysical data to provide background data for followup programs in fisheries.	- Species distribution, spawning areas, bottom sediments, fish productivity, capability. - Identification of benthic organisms.	- Expanded legends on geomorphological maps. - Detailed reports.	Information to be presented at 1:125,000 and/or 1:250,000.

Prerequisite Information		Required Sector Data		Phasing Requirements and Comments
Type	Scale and Coverage	Order and Scale	Format	
Sector: Forestry				
Surficial Soils Vegetation Water Imagery	Biophysical data provides basis for followup and more detailed forest survey programs (ie terrain limitations and reactions, relief, hydrology, climatic limitations, species requirements & dynamics). 1:50,000 recent or optimum coverage. Seasonal and sequential coverage.	Land capability for forestry for different management or planning levels (1:250,000-1:50,000).	Maps and text.	Must follow baseline surveys. Capability in part a derivation of primary resource data. Require derived information on maximum stream flow, erosion hazard, important fish areas, etc.
Topographic maps Airphotos Growth & Yield curves Management & technological criteria	1:16,000-1:13,200 with ground control. Representative of inventory areas. Alternative land use considerations, harvesting technology.	Present cover (commercial and non-commercial areas) and uses. Require information on species, communities, density, height, volume and distribution. General typing at 1:50,000. For management purposes 1:15,000.	Maps and tables showing actual state of forest cover. Absolute and economic volumes.	Forest cover should be mapped in conjunction with other user needs such as agriculture, wildlife, fisheries and recreation. Need constant update of forest cover maps & documentation of disturbed areas.
Sector: Recreation				
Base line data	Recreation survey requires input from all other disciplines and can therefore utilize available maps and imagery	Recreation can be shown as an overview at 1:50,000. However, for compatibility with other inventories uplands should be mapped at 1:250,000- 1:125,000. For shorelines mapping scale should be 1:50,000. - shorelines and river characteristics. - vegetation and fragility. - navigability (boat, canoe). - aesthetic and scienic qualities.	Map, legend & report.	Information at scales of 1:250,000-1:125,000 sufficient for upland areas. Information at scales of 1:50,000 or larger is required for shoreline areas or other areas where site-specific information is important. Require supporting information on wildlife populations &

Sector: Recreation (continued)

Prerequisite Information		Required Sector Data		Phasing Requirements and Comments
Type	Scale and Coverage	Order and Scale	Format	
Land Use	Require information on access, natural history, and areas of historical significance.	- terrain variability. - uniqueness and site attractivity. - natural or man-made hazards. - ski slopes. - ease of access.		dynamics, important habitat areas, etc. Need re-survey 5-10 year period; consistent updating of aerial photography. Program to map disturbed areas & insect hazard. Recreation survey should be conducted simultaneously with other surveys.

Sector: Wildlife

Type	Scale and Coverage	Order and Scale	Format	Phasing Requirements and Comments
Base line data Imagery	All other base line sector maps required, especially geomorphology and vegetation. In addition to imagery required for the above surveys, require low level photography for various species counts.	- habitat types (critical, productivity, carrying capacity). - census information. - species concentration. - endangered species habitat. - population dynamics. - migration routes.	Wildlife map & supporting legend. 1:250,000-1:125,000-1:100,000 (Same scale as geomorphologic map).	
Resource Use	Commercial, sport & domestic use of wildlife.			

DISCUSSION ON THE FINDINGS OF THE BIOPHYSICAL STUDY GROUPS

Discussion on Soils, Vegetation and Geology

Jurdant expressed concern about placing too much emphasis on ongoing timber surveys. For example, in terms of wildlife habitat, timber surveys did not provide much information. *Lavkulich* stated that what was being emphasized was the need to recognize and not duplicate these ongoing surveys. *Luke* felt that vegetation maps should not just indicate commercial timber, but commercial for what purposes. *Lemieux* felt that the regeneration also had to be considered in addition to the size of timber. *Fulton* commented that the scale of 1:125,000 should not be considered sacred — since the introduction of the metric system, mapped information may be presented at 1:100,000.

Discussion on Climate

Marsh outlined the work presently being undertaken in British Columbia regarding the types of climatic data being collected. He felt that more data were required in order to improve the reliability of the results. *G. Young* felt that it is up to the individual users to decide what the areas of concern are; the network could then be decided based on these needs. *Duffy* asked whether broad programs now underway should be considered under the heading of prerequisite information. *G. McKay* indicated that global programs are more related to an understanding of atmospheric energy changes. This broad information would feed into the program. *Duffy* inquired as to whether historical data (floods, droughts, etc.) should be fitted into the system and *G. McKay* agreed.
Duffy stated that it was necessary to go further than merely state that the data in the north was inadequate; it must be refined on a regional basis.
Lemieux felt that there are two things to consider: meteorology and climatology. Most northern stations are set up on the basis of transportation requirements. He also felt that greater use should be made of LANDSAT photography in this regard. *G. McKay* indicated that there were a lot of shortcomings in some of the climatic data and that it was essential to have a climatologist in on interdisciplinary activities involving the use of climatic data to get a correct interpretation of the data.
Brack wondered whether enough attention was being paid to permafrost and snow. *Strang* felt that it is also necessary to know more about things such as areas of high lightning incidence.

Discussion on Water

Lavkulich explained that the study group he chaired recommended that for integrated surveys special attention be given to all water bodies. *Stephansson* indicated that the Fisheries and Marine Service of Environment Canada has undertaken studies with respect to marine environments, although they have been largely management oriented. *Brack* indicated that little work has been done on groundwater in the north. South of the permafrost zone, work was ongoing in this regard, but he was unsure of the extent of such work.

Discussion on Renewable Resources

Strang felt that it was necessary to know the maximum harvest of renewable resources. *Romaine* agreed. *Wilmeth* pointed out that archaeological resources are not renewable. *Romaine* indicated that archaeology was combined with renewable resources only for the purposes of establishing broad category groupings.

CONSOLIDATION OF SOCIOECONOMIC DATA NEEDS

The study group established to identify socioeconomic data needs for northern areas began their session by posing two prerequisite questions that required followup and by outlining a number of related and overriding requirements.

Questions

1. Who requires socioeconomic data?
2. For what purpose does the user require socioeconomic data? eg:
   - Regional analysis.
   - Income distribution.
   - Investment opportunities.
   - Resources allocation planning.
   - Policy identification.
   - Present participation (Public).
   - Present land use.
   - Recreation planning & development.
   - Quality of life analysis.
   - Development impact.
   - Historical development of man, etc.

Followup Requirements

1. Specific goals & objectives should be stated by user.
2. User identification of socioeconomic & other data required.
3. Identification of data sources required.
4. Identification of data gaps required.
5. Need for data assembly.
6. Need for data analysis.

Following this, a number of socioeconomic data sets were identified and a number of related questions on socioeconomic data sources were raised.

Socioeconomic Data Sources

A wide variety of sources of data are available. No attempt was made to list these sources.

Questions

1. How are data collected - methodology?

Human Profile Sets	Social Data Sets	Work Income Data Sets	Leisure Data Sets
1) Age Sex Birth Rate Death Rate Origin Language 2) Aggregation sets Total Population Community Profile 3) Migration, etc. 4) Historical, etc. 5) Life styles 6) Cultural	1) Infrastructure Housing Water supply Sewage disposal Transportation Communications 2) Services Health Education Legal Welfare Protection 3) Organization Local govt. Leaders Decision makers 4) Ownership Land Resources Aboriginal rights etc.	1) Skills 2) Incomes 3) Job opportunities 4) Participation 5) Unemployment 6) Mobility 7) Zone of Activity	1) Availability 2) Participation Active Latent 3) Zone of travel, etc.

SOCIOECONOMIC DATA SETS

2. How are data assembled - systems?
3. How are data communicated or presented - networks?
4. Is there a 'primary' data-gathering group? Who?
5. Is there a 'secondary' data-gathering group? Who?
6. What relationships exist between 'primary' and 'secondary' groups?

The assembly of socioeconomic data is presently poorly organized. The study group made the following comments and suggestions as to the organization of socioeconomic data.

Comments

1) There are many sources for data.
2) There are areas of apparent overlap and duplication.
3) Data networks are poor.
4) Lack of linkage between data sets.
5) Information diffusion is poor.
6) Availability of data — legal constraints often restrict distribution of data.
7) Reliability or confidence level of data is often unknown.
8) Income data is not reliable.
9) Data required for objective are not related to data gathered.
10) Data become dated.
11) Need to aggregate data to specific study area.
12) Data assembly methods & procedures require standardization.
13) Methodology — questionnaire content requires examination.
14) Data presentation requires examination.

Suggestions

1) A framework is needed for collecting and presenting the two basic types of socioeconomic data:

   (a) Hard data, such as age, sex, etc.
   (b) Soft data, such as quality of life, etc.

Such data should form part of a longitudinal data set — ie data should be updated over time.

2) Inadequate representation of the socioeconomic expertise in Canada at this Workshop would indicate that a 'Socioeconomic Workshop' should be arranged for in the near future. The participants at such a proposed Workshop should address themselves to the following considerations:

   (a) Data sets within a 'framework' (eg 'primary', 'secondary', 'tertiary', 'longitudinal').
   (b) Data-gathering methodology.
   (c) Data-gathering units.
   (d) Data assembly.
   (e) Data networks.
   (f) Integration of socioeconomic-physical-biological data sets for purposes of servicing the planning, decision, and evaluation processes.

DISCUSSION ON THE FINDINGS OF THE SOCIOECONOMIC STUDY GROUP

Duffy expressed concern about the lack of coverage of psychological data (eg needs and desires of people). *M. McKay* indicated that the group covered this and recommended holding a workshop to look at the socioeconomic aspects.

Duffy also felt that if a separate socioeconomic workshop was set up that it should not be carried on in isolation from the physical aspects. *M. McKay* supported this position. *Brack* stated that he also supported the need for a socioeconomic workshop and that someone from the appropriate group within the Department of Indian Affairs and Northern Development should be invited to enable the workshop participants to benefit from the experience of this group.

Thie commented that integration has not yet been considered. He expressed the hope that a group would be set up that afternoon to look at this. The costs of surveys, time frame and benefits must also be discussed to arrive at an integrated survey. *M. McKay* indicated that the study group was looking at data requirements, not asking for surveys. *Romaine* explained that yesterday the study groups were examining data needs and that today they would be discussing methodology.

Seifried was of the opinion that it was not necessary to go through the same process in outlining physical data needs as it was in outlining social data needs.

Baker also felt that it was necessary to look at integration and to look at demands rather than solely capability. He felt that the important question to ask was why inventory at all? By asking that question, a whole range of things such as needs will be examined.

SUMMARY OF DISCIPLINE GROUP STUDY SESSIONS

For the afternoon of 18 April 1974, the Workshop was restructured into five discipline groups to utilize the results generated from the study groups as background information upon which:

1. To refine individual discipline data requirements.
2. To explore the commonality between selected discipline data needs and to suggest approaches for conducting multidisciplinary surveys.
3. Based on the above two points, to:
   (a) Provide objectives and definitions (criteria) for data sampling, collection and presentation at various levels (scales) of mapping intensity.
   (b) Outline general procedures for launching integrated surveys in northern areas.
   (c) Make recommendations as to followup courses of action that should be considered in conjunction with future northern survey programs.

DISCIPLINE GROUP DEALING WITH THE INTEGRATION OF DATA

The group addressed four basic areas of discussion.

Integration within the biophysical environment - The integration should provide for the delineation, definition and description of ecologically significant units. These units in turn can provide the base upon which derived information can be obtained. For resulting integrated maps to be of maximum utility, the degree of detail that should be provided on an integrated map and accompanying expanded legend is very important. It was the consensus of the group that there are really only two alternative approaches to survey programs in the north:

1) Conduct detailed surveys for select or priority areas. Such an approach would not provide complete coverage for the total area under consideration.
2) Develop a survey system which is less than comprehensive, or less than ideal, but which would provide the basic framework for a survey and which would provide sufficient information to subsequently focus on key areas. Such a system should also provide the flexibility to accomodate additional information as it is collected. The system should provide basic and static information from which derived information could be obtained. The level and nature of data collected should serve as a basis for broad policy and program decisions. Two primary considerations for conducting such a reconnaissance survey would be: a) the recognition of dollar constraints; and b) the recognition of time constraints — ie the survey should be capable of being completed within a reasonable time frame.

Integration within the socioeconomic data system - Within the socioeconomic area, numerous data sets and numerous levels of information exist. However, integration of these various data sets apparently does not exist. A system for integrating these various data sets within a single framework of socioeconomic information is required. Perhaps a parallel system (ie hierarchy) can be developed to be compatible with a proposed system for integrating biophysical data.

Integration of the socioeconomic data with the biophysical environment data -

1) Integration has various meanings. It may mean integration of the data-gathering process, (ie the logistics or operational aspect) — the people gathering biophysical information share the same field camp or helicopter in collecting information, but two separate data sets are collected. It could mean integration of information in the field — the biophysical resource survey team also contains counterparts with socioeconomic expertise. Biophysical information gathered during the day is interpreted in the light of what the socioeconomic expertise has gathered and vice-versa. It could mean the collection of separate data sets in the field, but subsequent integration of data when the information is being compiled, analyzed and documented. Or, integration could be related to the level at which information was being gathered (eg at the broad reconnaissance level, integration may not be necessary, but integration may be required at a more refined level and for selected areas, such as in and around communities, along transportation corridors, etc.).
2) The discipline group agreed that the survey group's function was to provide information to the user or the planner — it should not assume the role of the planner. This distinction may be difficult to make when

the data gatherer begins to undertake the integration of information. However, liaison between survey groups and planners is required.

3) Separate data sets could be collected, but these data sets should: 1) be carried out consistent with phasing, determined on the basis of priorities set by decision makers (ie if information is required for a certain area for a specified purpose, both sets should be gathered in phase with each other); and 2) ensure that the information is collected in a manner that provides for compatibility between the two sets. There was consensus that there were basically a number of levels of information, each level having its own degree of detail.
   a) Primary level data is basic, largely static and objective information covering such components as land, geology, soil, topography, water and climate.
   b) Secondary level data is primarily derived or interpretive information, such as the capability for minerals, vegetation, wildlife, fish and recreation.
   c) Tertiary level data is required to assess environmental impacts, socio-economic consequences, etc.

On the socioeconomic side, a similar hierarchical classification system can perhaps be made, but this requires refinement. Parallel levels of information could include:
   a) Primary level data may include demography and perhaps demand.
   b) Secondary level may include human or people wants, aspirations, economics, opportunity, etc.
   c) Tertiary level includes the impact upon society.

   The problem of the survey team is to anticipate the information that is required to answer questions at the tertiary level.

4) Before an attempt can be made to integrate the socioeconomic data with the biophysical data, a common base is needed. Base information for both of these study areas should be prepared in a compatible manner.

Where do we go from here?

1) On the socioeconomic side, it was suggested that a followup workshop be convened to deal with that aspect.
2) On the biophysical environment side, the group discussed this in the light of cost and time constraints. Of the two alternatives — detailed surveys in selected areas versus 'broad brush' reconnaissance survey — the group preferred the latter primarily because: a) it would provide the basis for the subsequent selection of priority areas requiring more detailed investigations; and b) it would provide an overall framework within which a common approach or system can be devised and to which detailed information can be related. In light of this preference, the group explored how such a survey could be achieved, what information could be provided at this level of survey and what the cost of such an undertaking might be. Based on Jurdant's comment, the cost of conducting a biophysical survey was approximately $90,000 per map sheet — equivalent to some $56 million for northern Canada, which is perhaps an unrealistic expenditure. Such a survey would require too long a time frame to provide complete aerial coverage. A survey which would cost under $40,000 per map sheet and within a time frame of 2, 3 or 4 years would be more realistic. Within that context, the group explored tools and techniques. Remote sensing apparently has much to offer, although the application has to be further refined. By combining remotely sensed data with conventional information, it is quite realistic to think in terms of a fairly good, basic survey framework being conducted at relatively low cost. In such an approach, the land unit and description would be reliable and it would accommodate further refinement. The basic difference between this approach and the more detailed studies being presently undertaken (eg the James Bay project) would be in the description of the land units, and the amount of supporting fieldwork.

Discussion on discipline group findings - *Borys* commented that Manitoba is anxious to commence a reconnaissance survey. Cost and time required for such a survey are of considerable concern. The province has held a number of preliminary discussions as to how surveys could be performed, and *Borys* now felt that they could begin a pilot project this year with the objectives of such a study being:

1) to develop a survey system that provides for a broad brush reconnaissance survey and allows for the accommodation of refined and detailed information;
2) to explore the application of remotely sensed imagery in conducting such a survey; and
3) to provide a reconnaissance survey for northern Manitoba within three years with a budget of under $500,000.

Such a pilot project would have mutual benefits both to the province and nationally. *Borys* indicated that Manitoba could not wait until

an ideal national approach was developed. The pilot project could also provide the laboratory for testing techniques and application of new methodologies (eg how much information can be accommodated; research relating water units and land units; etc.). The development of the pilot project should take place under the direction of a provincial advisory group, which would work in harmony with a national advisory group. *Borys* closed by assuming that there would be followup to this workshop and that discussions would continue to take place until a program (or at least framework guidelines) is developed. *Duffy* raised two points: 1) it was indicated that systems are available to carry out integrated surveys, but we do not have a full record of our progress in developing a Canadian integrated survey. Therefore, it might be presumptuous to say that we have the system developed; and 2) not only time and money constraints must be considered, but also the constraints of institutional arrangements. *Borys* agreed that considerable discussion and refinement was necessary in the integrated approach, but the basic philosophy exists. It is now possible to proceed with a certain degree of confidence in delineating ecological units. *Jurdant* felt that further discussion on methodologies would likely achieve little action, citing an example from Quebec. Until people work together in the field, no progress will be achieved — the time is right for action to undertake an integrated survey.

DISCIPLINE GROUP DEALING WITH GEOLOGY, SOILS, AND VEGETATION

The group discussed the purpose of land surveys in the northern parts of the provinces and in the northern territories — ie why and for whom are the surveys to be done? Potential users of land survey information range from those who make broad political decisions to those who have to make local, site-specific decisions during construction projects. Thus, the type and intensity of information which each level of user needs differs significantly. The survey system has to be designed so that it has the potential to satisfy all those demands within its framework. In other words, the components of the landscape to be included (eg soils, geomorphology and vegetation) would be the same throughout, but the parameters measured would differ from region to region and in time, depending on the user requirements.

The working group then discussed possible approaches to carrying out land surveys in northern Canada. The consensus was that independent sector surveys should be replaced by an integrated survey system, carried out in the field by joint multidisciplinary teams, which would produce common base maps and/or other documents emphasizing the stable or fundamental components of the landscape. These documents or maps would then form the basis from which any required interpretive classifications could be made (eg capability or sensitivity ratings). However, the preparation of this integrated product should not eliminate the parallel production of such sector maps as surficial geology maps or soil survey maps from the data collected as part of the integrated survey.

To continue planning for integrated land surveys in northern Canada and to subsequently implement and coordinate them, the group makes the following recommendations:

1) A followup workshop should be held to critically examine the data requirements by users to ensure that the integrated survey system will be capable of generating all the required information.
2) A national technical coordination committee (similar to the Canada Soil Survey Committee) should be formed to generate guidelines for the survey system, to standardize methods and terminology and to coordinate the scheme nationally, provincially and regionally.
3) A permanent central administrative body in the federal government should be formed to technically and administratively oversee and coordinate future survey work. Such a body should contain field staff in the core disciplines and should also be responsible for conducting training exercises and pilot projects in the field.

Discussion on discipline group findings — *Fulton* felt that the group was suggesting the abolition of sector mapping. He felt that we must be careful not to tell bedrock geologists, for example, that they should not map. The important point is that in the areas where integrated surveys are being carried out, individual sector maps should not be prepared. *Strang* indicated that the point Duffy raised regarding institutional arrangements is implicit in what *Dirschl* mentioned regarding the establishment of a coordinating body.

DISCIPLINE GROUP DEALING WITH CLIMATE

The group began its session by formulating the following questions and answers.

1) *Who is the client?*
The group was split, but considered the planner to be the client. It was felt that there was

a need for an overview and that suitable overviews would be provided by map scales of 1:250,000 or smaller. In areas of rugged terrain, scales of 1:50,000 were necessary.

2) *Is there a need for climatic data?* Climate is the integration of energy, moisture, light and other atmospheric ingredients which are essential to life and growth. It controls man's activities, and limits his ability to alter use acceptably. Climate is manifest in soils and in plants and other life forms; surveys of these factors disclose climate, but for modification or alternative use, other manifestations or measures of climate are essential.

3) *What does the client need?* The group could not competently answer the question in a broad sense. Before needed information can be properly assembled, the purpose must be known. Real problems must be addressed or efforts made to develop data acquisition and processing, and mapping may be a costly and unacceptable waste. The group attempted to cross this step by considering problems which the developer might confront. For example, agriculture has been proposed for the discontinuous permafrost zone. The Group considered that an agricultural capability map could be prepared using such elements as soil temperature, air temperature, precipitation, growing season length, etc. Other potential northern developments were similarly considered.

User needs could be handled by providing derived information such as capability maps which could be directed towards each specific use or alternatively by identifying major climatic features, such as snow cover, which are critical to almost all life and related activities. For both approaches, however, the climatologist needs to sit down with the planners to evolve the best information systems or presentation to meet his need. The group's findings on this aspect are summarized in the next column.

4) *Is it possible to provide this information?* In an interpretative sense, it is possible to develop this information by using physical relationships, LANDSAT imagery and existing networks' techniques. However, this must be qualified by stating that:

(a) Physical relationships must be understood in order to remove the bias in existing weather information, since most climate stations are in sheltered locations. That is, stations frequently were established in areas convenient to transportation, settlements, etc. and are therefore often unrepresentative for larger areas.

(b) Information presented would be highly generalized. Possibly interpretative maps could be provided at scales of 1:1,000,000-1:500,000. At present accuracy would be poor for larger scales such as 1:250,000.

The Group then proceeded to identify terms likely to be necessary for the development of interpretive maps as noted on the following page.

Subject Area	Climatic Data Needs	Interpretative maps
Agriculture	Soil temperature Frost-free period Rainfall intensity Growing degree days Rainfall Radiation Air temperature in summer	Capability Limiting factor map Biological capability
Energy developments	Inversions	Hazards
Settlements	Ventilation Precipitation Snow cover Wind & low temperatures Wind Fog	Capability Soil stability Snow resources Precipitation Water
Transport, highways	Wind Snow cover Access & logistics Hazards map	Snow cover (depth & distribution) Industrial siting
Mineral res.		Inversions
Recreation	Snow cover	Capability

Resources	Snow depth & control	Season length	Exposure and wind chill	Extreme temp.	Good working index	Ava- lanche hazard	Specific hazards	Ice clearance, duration and formation	Air temp.	Precip- itation	Evapo- ration	Radia- tion	Soil temp.
Agricul- ture	*	Frost free period	wind	*			Drought, haying moisture excess; harvesting weather		Grow- ing degree days	*	*		*
Forestry	*	*	wind	*			Drought, fire, light- ning and insects		*	*	*	*	
Wildlife	*		*				Drought, moisture excess		*	*		*	
Recreation	*	*	*	*	*	*	Wind, storms, fog	*	Winter & summer capability				*
Energy Development	*	*		*			inversions, ice, wind ventilation hazards		*	*			
Transportation & Access	*	*	*	*	*	*	Fog, high winds, storms, visibil- ity		*	*			
Operational Working Index	*	*	*	*	*		Visibility	*	*	*			
Water	*	Open	Winds for setup waves				Drought, floods, yield		*	*	*	*	
Mining (open-pit & other)	*	*	*	*	*		Inversions; ven- tilation	*	*	*	*		*
Settlements	*	*	*	*	*	*	Inversions; ven- tilation	*	Sewage lagoons	*	*	*	*
Fisheries		*	Wind		*		Fog, ice	*	*	*		?	

Recommendations

1) Greater communication is needed between all disciplines involved in future survey programs.
2) There is a prerequisite requirement to identify the availability of existing information, to make use of large amounts of already available data which are being ignored, and to determine additional data needs.
3) Techniques are needed for the preparation of integrated planning maps which adequately interpret disciplinary information in terms which can be easily understood and used in the planning process.
4) More intensive programs are needed to provide improved measurement and processing of data such as:
   a) The establishment of observation stations (meteorological and climatic networks) in areas whose climate is representative of land-use units and the identification of biases in data by establishing the context (soils, vegetation cover, landforms, etc.) within which meteorological measurements are made.
   b) The exploitation of new technology and the collection and assimilation of fragmentary records from previous survey groups and historical data on previous climatic episodes and fluctuations.
   c) The development of techniques and models needed for data transposition, extrapolation, interpolation, etc., with respect to vegetation, topography and other physical factors.
5) For future programs, where and when possible, survey teams should collect particular climatic data for subsequent interpretative purposes.
6) A climatological technical committee should be considered; its aim would be to bring climatologists and planners together to resolve those problems identified above and to develop a system so that useful information is put back into the planning process.

DISCIPLINE GROUP DEALING WITH WATER

A) *General statements*

1) Three broad climatic regions were identified:
   a) medium-heavy precipitation; little or no frozen ground
   b) medium-low precipitation; some frozen ground
   c) low (desert) precipitation; frozen ground

   In region (a), apparent abundance of water could lead to misuse or mismanagement of the water resource; in (c), water supply could be a critical factor in major development. There have already been supply problems in two quite large settlements in the Arctic. Waste disposal problems also have to be considered.
2) Within the North, consideration should be given to:
   a) freshwater bodies
   b) groundwater (with frozen ground complications)
   c) saltwater areas
   d) estuaries

   The group did not address itself to saltwater areas and estuaries.
3) Moving from the relatively densely settled and highly used landscapes of the south into the sparsely settled and sometimes uninhabited natural landscapes of the northlands we find:
   a) deficiency of data compared with what are readily available in the south; and
   b) user needs for the northern areas are poorly documented.

   Both the supply of and demand for information are therefore uncertain; with increasing activity in the Northlands, however, demand can be gauged, at least qualitatively, and supply can be improved.
4) Reliable data on water quantity and quality require a 10-year recording period, but user needs are likely to become known only within a shorter period. Given a particular demand in a specific area, water surveys can be mounted relatively easily, provided that money and manpower are made available, but the results would lack the reliability of long-term stations.
5) Because of the increasing pace and scale of penetration into and activity in the Northlands, there is an immediate need for a means of compiling biophysical data of a reconnaissance nature rapidly throughout the Northlands, and integrating the data on an area basis, pending notice of area-specific activities whose data needs can be met by special more-detailed surveys.
6) Water information has not yet been compiled in map form in a manner useful to scientists, administrators, and the private sector.
7) Water information is more important to all other sectors than may have been suspected, and could be a dominant factor in future environmental considerations.

B) *Water information and methodology*

1) Information is required on eg:
   - quantity
   - fish populations

- quality as now available
- depth of lakes
- flood incidence and hazard
- scenics
- storage
- power potential
- use by wildlife
- winds
- ice cover
- transport capability
- potability

2) More water information could be acquired (at least on a provisional basis) through:
   a) inference and interpretation from other disciplines;
   b) local knowledge (eg outfitters, prospectors, RCMP and local people);
   c) interpretation and extrapolation of imagery (eg LANDSAT and infrared photography); and
   d) water-related programs of non-water organizations (eg Wild Rivers Program of National Parks and drill records of exploration and transportation companies).
3) The presentation of water information should go beyond the prevailing tabulation format and include:
   a) mapped information;
   b) description and extended legends on topographic maps, geology maps, and other maps where practical and if required (eg vegetation and wildlife maps);
   c) special maps of the water domain (subject to user needs becoming known); and
   d) derived maps — incorporating the judgements of other disciplines.
4) 'Market' survey to determine user needs
   - consultation with users as to nature and accuracy of information required
   - administrators
   - private sector
   - scientists, etc.
5) Assess network effectiveness.
6) Map water characteristics on a regional basis.
7) Treat water as an integral part of the ecosystem, not as a separate item.

C) *Conclusions*

1) In the southern part of the Northlands, apparent abundance of water could lead to its misuse and mismanagement; in the drier northerly parts, water supply could be a critical factor in large-scale development.
2) Water could be a dominant factor in environmental considerations in the future.
3) Except in a few instances, the present water networks and state of documentation on water bodies in the Northlands are inadequate for environmental assessments, for providing reliable long-term information for development purposes, and for inclusion in an integrated biophysical survey.
4) The presentation of water information in various forms (eg mapping) requires study. The prevailing mode (tabulations) has limited value and does not readily satisfy the perceived needs of a variety of users (eg scientists, administrators and planners, in both the public and private sectors).
5) The water sector should endeavour to plot and compile more information on water bodies through the expanded use of imagery, and inference from other disciplines.
6) The authorities for federal participation in an integrated biophysical program are already available (eg CWA, NWA, NWPA, the Wild Rivers Program of National Parks, and other on-going programs). A biophysical survey of the Northlands could be a useful contribution by Canada to the Man and Biosphere (MAB) program of UNESCO.
7) Because of the scale and pace of penetration and development in the Northlands, there is an immediate need for fuller documentation of water information and integration of water information into a biophysical program — initially on a rapid and broad reconnaissance basis.
8) Marine waters were not discussed at this Workshop.

D) *Recommendations*

1) Future discussions on the water sector should include marine and estuary expertise and representation from the private sector.
2) The prospects for acquiring information on groundwater and frozen ground from the extractive industries should be explored.
3) The biophysical classification should be amended to include information on the water sector, and biophysical methodology should be amended to take into consideration the resource survey needs of the water sector.
4) Pilot projects to determine the techniques for integrating water information into a biophysical program, and making full use of available imagery and interdisciplinary inference should be initiated on a map sheet or drainage basin basis.
5) A permanent national committee on land and water is required to establish national

classification methodologies and modes of presentation.

Discussion on discipline group findings - *Baker* asked for a brief summary of the state-of-the-art in classification of water resources. *Jurdant* indicated that in Quebec, the Department of Natural Resources was interested in mapping water in terms of its physical and biological properties and that they separated Quebec into southern and northern areas. *Brack* indicated that information had not been mapped in a manner which permitted the mapping of water. He felt that some information on water should be collected in the biophysical survey. *Lemieux* expressed the opinion that the major problem in the water field, at least in Quebec, is that there has been no over-all attempt to carry out a long-term survey. There is a great deal of raw data available, but there has been no attempt to develop a classification system. *Thie* felt that the problem with water is that spot sampling is required. Remote sensing would appear to offer considerable possibilities in this regard. *M. McKay* indicated that a lot of information is available; however, it is scattered all over. The problem is to gather all of this information together into one package. *Duffy* felt that fisheries involvement was also required. *Baker* indicated that there was a lot of information available on fisheries (eg in the N.W.T.), but there are many problems in trying to relate it to angling or productivity. *Lemieux* summarized the foregoing discussion by stating that a national committee is evidently required to get the water people working with ecologically oriented people. In addition, the users must identify their data requirements.

DISCIPLINE GROUP DEALING WITH RENEWABLE RESOURCES AND ARCHAEOLOGY

The Discipline Group identified its objective as being *to provide a data base, for broad planning and management decisions, which would be acceptable or applicable at a national level.* Data presentation at a *scale of 1:250,000* was selected as being most appropriate. The various resource sectors were then discussed in detail.

A) Forestry

For carrying out forest survey programs, the following data is required:
1) Prism plots or transects as basic survey data
2) Growth curves
3) Species identification
4) Present volume
5) Forest zonation

In some areas of the provinces, there is adequate existing data at a suitable scale and hence no particular studies are required. For those northern areas of the Provinces and the Territories that have not been previously surveyed, data for forestry could be derived in part from other baseline surveys. Such studies would have to be supplemented by forest sample plots to identify commercial areas and areas of high productivity.

B) Wildlife

The group concurred with the Canada Land Inventory (CLI) approach for mapping wildlife capability. Such data should be expanded and supplemented to include:
1) Basic surveys on species distribution and abundance.
2) Expansion of CLI grouping to include furbearers and endangered species.
3) Identification of sensitive habitats and critical areas such as migration routes, concentration areas, calving or post-calving areas, etc.
4) Delineation of broad areas used by upland game birds.
5) Incorporation of local or native groups' knowledge about animal resources of a region.

C) Agriculture

Suitability or capability maps can be interpreted from other baseline information such as soils, geology and climate.

D) Fisheries

What is required is a capability rating supplemented by information on fish populations, spawning areas, migration routes, overwintering, feeding, nursery areas, etc. More information is needed on water, and there is a need to coordinate fisheries data requirements with the location of water stations. Some of the information relevant to fisheries could be interpreted from baseline data on water chemistry and water quality.

E) Marine Mammals

More information on marine mammals is required. By documenting distribution and abundance it may be possible to produce capability maps and to identify critical areas such as denning areas for polar bear or ooglits for walrus. The classification and distribution of ice types is an essential part of the baseline data needs for marine mammals.

F) Recreation

Further discussions with the provinces are required to define particular recreation data needs. A departure from the CLI approach is needed to place more emphasis on the uniqueness and/or quality of an area. In northern areas, wilderness and discrete esthetic values are probably more important than the intensity of use. Carrying capability in terms of fragile areas or trafficability are also important, and much of this information could be interpreted from other baseline data sources.

G) Archaeology

To avoid the problems of scavenging, specific sites should not be mapped. Maps could be prepared, however, which would identify the likelihood of occurrences (ie sites where remains are likely to be found, such as traditional camping or settlement sites which are often associated with river mouths, raised beaches, passes, etc.). Some of the information could be derived from other baseline data. Following excavation, maps could be prepared to show relative site densities for regional or areal comparisons. Cultural interpretation maps based on pre-history land use and occupancy would also be valuable.

General comments

1) The group emphasized developing an overview approach to mapping. A reconnaissance survey would allow for the general identification of critical or important areas that should be considered in the planning process, and would also provide for the identification of particular areas and studies that require followup attention. Given a specific project or development, methodologies and programs could then be developed for that purpose.
2) Water was recognized as a renewable resource, but it was assumed that this component was being handled by the water discipline group.
3) Present land use, although not discussed because of time constraints, could probably also be handled at 1:250,000 with a larger scale being required for problems or data relating to urban or settlement matters.
4) There was a general feeling of lack of direction or guidelines on discipline group goals, and it was thought that the group's productivity in the afternoon session suffered as a result.
5) Followup sessions are needed to further explore the questions and problems that have been discussed in this workshop. Few concrete solutions, methodologies, or recommendations could be developed, and followup sessions are needed to take advantage of the progress registered to-date, and to determine where to proceed from here.

OPEN DISCUSSION

M. McKay opened the discussion by posing two questions:

1) What happens to the recommendations now?
2) Where do we go from here?

These concerns were also expressed by others. *Baker* felt that one concern raised at the meeting was an ignorance of what was going on in the North. He felt that the group that would follow-up on the results of the workshop. Would have to assemble a consolidated document on what is going on in the north. *Brown* replied that presumably one of the functions of a national land classification committee, which it was felt was desirable, would be to assemble this information. *M. McKay* indicated that each jurisdiction has its own concerns and its own way of handling these concerns. The concern of this workshop is where do the recommendations go at the national scene. Action will be taken in each jurisdictional area, but have we moved any further in bringing this to a focus at the national scene? *Coombs* responded that various federal agencies have various responsibilities and that there is a growing federal concern for broad national land use policies and programs. He felt that the recommendations could be channelled into various on-going committees. *Duffy* stated that the recommendations reflected the technical aspect. Program administrators are bound to take action. We are presently concerned about the delivery point of the recommendations; rather, the recommendations of the various groups should be examined to see if there are any which the group as a whole disagreed with. He felt that the purpose of the plenary session was to obtain general agreement on recommendations generated by the individual groups. *Brown* noted that the recommendations will go to all agencies concerned.

Individual recommendations were examined, and it was concluded:

1) that the Manitoba pilot project will proceed;
2) that more input is required from the water sector;
3) that greater communication is needed between disciplines and between physical and social sciences; and
4) that a continuing technical committee is needed.

CLOSING REMARKS

M.J. Romaine
Lands Directorate
Environment Canada
Ottawa, Ontario.

Rather than attempt to summarize the findings of this workshop, I would like to pose an analogy between what happened approximately fifty years ago and what has been discussed at the workshop. The early part of the 1900's saw the rapid development of the western provinces, an area then referred to as Canada's frontier. Most of the developments at that time were linked to an agrarian lifestyle and the exploitation of renewable resources. Due to the lack of base line data, land use decisions and land alienation policies and programs bore little or no relationship to the land's quality or potential. It was at about this time that soil surveys commenced in Canada, although such surveys were based upon a young science and had limited trained personnel and funds; hence, they provided only limited information and utility to resource decisions made during that period of development.

The decade of the 1930's, however, underlined the errors made in previous land use decisions, and since that time, base data as provided by programs such as soil surveys have served an increasingly important role in dealing with land use problems and programs.

Today, half a century later, the seven provinces with areas extending beyond the northernmost limit of the CLI boundary, as well as the Yukon Territory and Northwest Territories, are all proposing, planning or implementing major development programs in areas now considered as Canada's frontier. As distinct from southern areas, these developments are primarily concerned with the exploitation of non-renewable resources. Due to overriding climatic limitations, interest in developing renewable resources is secondary. There are some significant exceptions, however, where developments are based upon hydro-electric potential, and the manipulation of natural systems. These northern development programs, which tend to be on a large scale and are often located in remote areas, are lacking in base line data and are on a tight completion schedule. If we wish to avoid a parallel situation to what happened fifty years ago, the need for base line data is obvious. The workshop discussions, however, have pointed out that a classification system for conducting integrated base line surveys is still a relatively young science, and that there are presently limited trained personnel and funds for implementing such integrated surveys. Major commitments by provinces in their northern areas indicate that they take their northern areas seriously. For this reason, we must also give serious consideration to Canada's Northlands and the resulting recommendations made at this technical workshop.

SUMMARY OF RECOMMENDATIONS

SPECIFIC RECOMMENDATIONS

A) Climate

Consideration should be given to the establishment of a climatological technical committee with the purpose of bringing climatologists and planners together to deal with the following requirements:

1) There must be greater communication among all disciplines involved in future survey programs.
2) Existing information must be identified and additional data needs must be determined.
3) There is a need to develop techniques for the preparation of integrated planning maps which adequately interpret disciplinary information in terms which can be easily understood and used in the planning process.
4) More intensive programs are needed to provide improved measurement and processing of data such as:
    a) The establishment of observation stations (meteorological and climatic networks) in areas whose climate is representative of land-use units and the identification of biases in data by establishing the context (soils, vegetation cover, landforms, etc.) within which meteorological measurements are made.
    b) The exploitation of new technology and the collection and assimilation of fragmentary records from previous survey groups and historical data on previous climatic episodes and fluctuations.
    c) The development of techniques and models needed for data transposition, extrapolation, interpolation, etc. with respect to topography, vegetation and other physical factors.
5) For future programs, guidelines are needed to assist survey teams in the collection of that climatic data required for subsequent interpretative purposes.

B) Water

1) Future discussions on the Northlands water sector should include marine and estuary expertise, and representation from the private sector.

2) The prospects for acquiring information on groundwater and frozen ground from the extractive industries should be explored.

3) The biophysical classification should be amended to include information on the water sector, and biophysical methodology should be amended to take into consideration the resource survey needs of the water sector. Special attention should be given to all water bodies, including water quality (sediment, stream load, bed material, water quality-chemical), especially by programs of the geology, soils and vegetation sectors.
4) Pilot projects, to determine the techniques for integrating water information into a biophysical program, and making full use of available imagery and interdisciplinary inference, should be initiated on a map sheet or drainage basin basis.
5) A permanent national committee on land and water is required to establish national classification methodologies and modes of presentation.

C) Renewable resources

Follow-up sessions should be held to further explore the questions and problems that have been identified and to devise approaches for follow-up resource survey endeavors.

D) Integrated surveys

1) A follow-up workshop should be held to critically examine the data requirement by users to ensure that the integrated survey system will be capable of generating all the required information.
2) Sector surveys should be replaced by integrated surveys. Stable or fundamental data should be presented on a common base, but the preparation of an integrated survey should not prevent the production of individual sector maps within the integrated system. Integrated survey should be conducted from the general to the specific. The presentation of resulting data should:
    a) use maps, charts, tables and figures to maximum advantage;
    b) contain an extended legend and narrative as necessary;
    c) explore the utility of photo base for resource sectors that relate to present land use; and
    d) explore the utility of 3-D or block diagrams.

E) Socioeconomic

A socioeconomic workshop should be convened in

the near future. Such a workshop should have broader representation of the socioeconomic expertise in Canada. Representation should also include specialists from the biophysical sciences as well as greater participation from identified user groups. Items for consideration by this proposed workshop should include:

1) Data sets within a "framework", such as "primary", "secondary", "tertiary" and "longitudinal".
2) Data gathering methodology.
3) Data gathering units.
4) Data assembly.
5) Data networks.
6) Integration of socioeconomic-physical-biological data sets for purposes of servicing the planning, decision, and evaluation processes.

GENERAL RECOMMENDATIONS

a) A national technical coordination committee (similar to the Canada Soil Survey Committee) should be formed to generate guidelines for integrated surveys, to standardize methods and terminology and to coordinate approaches nationally, provincially and regionally.

B) Consideration should be given to the designation or formation of a permanent central administrative body in the federal government that would technically and administratively oversee and coordinate future survey work. Such a body should contain field staff in the core disciplines and should also be responsible for conducting training exercises and pilot projects in the field.

C) Consideration should be given to the development of a centralized bibliography resource bank in which all previous work is catalogued. Information from the private sector should also be obtained (eg drill hole logs, etc.).

D) Ways and means should be explored to develop feed-back mechanisms to universities to ensure the training of competent personnel.

SUPPORTING BACKGROUND PAPERS PREPARED FOR THE WORKSHOP

PLUS (PLANNING LAND USE SYSTEM)

J.H. Ross
Lands Directorate
Environment Canada
Ottawa, Ontario

INTRODUCTION

In recent years, to facilitate land use planning several computer systems have been developed, the majority of which have been based on a *fixed grid*. With this approach, a grid is drawn over the study area and the data are coded manually, assigning to each grid cell the characteristics of the map coverage overlain by that cell. Systems presently using the fixed grid approach include NARIS, CLUIS, the Lombard North system, and that of the British Department of Environment. An alternative approach is the *polygon storage mode* in which the input data are recorded as a series of irregularly shaped areas (faces) delimited by a series of straight lines which approximate the boundary of each face. The Canada Geographic Information System (CGIS), holder of the Canada Land Inventory (CLI) data, uses this mode. The polygon approach is more accurate (ie the original can be replicated almost perfectly) and is independent of input scale, orientation and projection. The fixed grid data, however, are much less expensive to manipulate than polygon data.

Despite certain methodological difficulties, computerized land use planning systems have a great potential, and existing systems can manipulate and display large amounts of data very efficiently. Their chief disadvantages are the cost of data input, the rigidity of the decision-making mechanisms built into the systems, and their general incomprehensibility to the non-computer-expert land use planner. The Lands Directorate, in consultation with Parks Canada, has devised and preliminarily tested a computerized land use planning system designed to overcome these difficulties while retaining speed and consistency. This paper aims to describe the Planning Land Use System (PLUS) and to discuss its progress to-date. PLUS is not completely tested, however, and we are presently not in a position to assess its full potential. Ways of improving or extending it will be suggested.

BACKGROUND

In September 1972, J. Beaman (Parks Canada) and I reviewed existing practices in the field of computerized land planning. Several deficiencies, the most important of which are outlined above, were noted and we decided to investigate the problems and prospects of a system which avoided these difficulties. Preliminary discussions were held with M.F. Goodchild of the University of Western Ontario to further explore the technical feasibility of such a system. These discussions led to a report ('A Position Paper on Geographic Data Processing', written by Goodchild under commission to Parks Canada) which concluded that such a system was technically feasible, and could be made operational by April 1974. Goodchild recommended that the polygon mode be used for data input and intermediate storage and that these data should be gridded mechanically prior to their use in decision-making or mapping where speed, cost, and simplicity are important.

In April 1973 it was decided to develop and test the proposed system, and Goodchild was commissioned by the Lands Directorate to prepare the necessary programs and to reduce a set of test data which might be used for demonstration purposes. The Lands Directorate assigned W. Swanson to the project to locate and prepare input data for reduction. In March 1974, Goodchild and Swanson demonstrated the operational PLUS system to officers of the Directorate.

THE PLANNING LAND USE SYSTEM (PLUS)

Basic Objectives of PLUS

The basic objective of PLUS is to provide to land use planners a comprehensive, flexible tool which they might readily use to prepare and evaluate alternative land use plans. This tool must be comprehensible to those without extensive computer backgrounds, and must be operable

at locations where large computer installations are not available. A second objective of PLUS is to permit the planner to incorporate local data in his planning without going through complicated data entry routines.

Basic Requirements of PLUS

1) To overcome the inherent inflexibility of grid storage, the system had to be based on polygon storage of raw data. Because the final data manipulation was to be performed on a grid basis, it also had to have the capability of accepting pre-gridded data.
2) It had to be flexible for scale, projection, orientation, coordinate system, and subject of the input data.
3) It had to be usable to planners with limited computing backgrounds.
4) It had to be capable of handling point, line and areal data types.
5) It had to facilitate the statistical analysis of land-based data in order that inherent relationships might be modelled for later use.
6) It had to be operable on equipment which might be used by land use planners where large computer installations are not available.
7) It had to be able to utilize existing data banks as well as to integrate locally collected data.

It soon became evident that it would be impractical to design a system which met all these requirements and was simple enough for the non-expert computer user. Accordingly, the system was divided into two separate parts. *PLUS I*, the data reduction phase, to be operated by a computer technician, would perform all the operations necessary to convert the input polygon data to grid data at the required scale and orientation. *PLUS II*, the synthetic phase, would be operated by the planner, utilizing simple commands to direct the computer to execute the decision rules he inputs, and to portray the results in either graphic or tabular form.

PLUS I

The purposes of PLUS I are to accept input data in polygon, line or point formats, to perform the necessary scale transformation and coordinate rotations, and to output the data in a grid format, at any scale or orientation requested. The system is subdivided into separate program packages, each of which performs a specific task in this data reduction. Point data can be allocated directly to their appropriate grid cells, but line data (treated here as long, thin polygons) and polygon data require some manipulation.

Polygon data are generally input to PLUS I in a format referred to as 'image/centre' (IC), in which all the polygons (faces for a given subject coverage are input, followed by a list consisting of the description of each face and the coordinates of one point within that face. These IC data are checked for accuracy, edited if necessary, and may then be numerically gridded. Data may also be converted into the Fairwise Contact (PC) for storage for future use. PC data are more efficiently stored and manipulated than IC data. Polygon data obtained from data banks (eg CGIS) to-date have been input to PLUS I in the PC data mode. The form of future polygon data input will be determined on the merits of each case, and either form of input would be acceptable.

Polygon data of the PC type are again checked for correctness, and then either put into temporary storage or allocated directly to the designated grid. At this point, the gridded data may be mapped easily with one of the Symap-type printer mapping packages, or they may be used in several different analysis packages. For example, by merely recoding the data, one might use a standard multiple regression package to investigate relationships among different map coverages.

The purpose of PLUS is not to create large data storage banks, but rather to use information now available and to supplement this with locally produced data (data which have been coded will be retained for future use if deemed necessary, but no large data banks are anticipated). The table below, which enumerates some of the data processed for the for the Lands Directorate's Roseau River Basin Study, indicates the wide range of data which can be processed by PLUS I. Plus I has so far operated relatively smoothly, although a few problems have been caused by differences in computers.

Original Data Name	Data Type	Data Scale	Source	PLUS Data Name
CLI Agriculture	polygon	1:250,000	CGIS	AGD
CLI Forestry	polygon	1:250,000	[1] CGIS	FGD
CLI Recreation	polygon	1:250,000	CGIS	REC
Depth of Water Table	polygon	1:126,720	[2] Agriculture Canada	SIG
Surface pH	polygon	1:126,720	Agriculture Canada	S2G
MCIC	point	no scale	Manitoba Crop Ins. Corp.	MCIC
Forest Inventory	polygon	1:63,360	Manitoba Gov't	MFI
Water Balance	polygon	1:126,720	Agriculture Canada	WBG
Census	polygon	1:250,000	Statistics Canada	CEN

[1] Three other coverages are available from this source.
[2] Twelve other coverages are available from this source.

PLUS II
The synthetic phase of PLUS aims to permit the planner to perform arithmetic and logical operations on the gridded data so that he may prepare a land use map from the data at his disposal, tabulate areas of special concern on such a map, display the map for visual checking, and then, if desired, modify the operations which led to the map to create another which is more suitable.

While discussing the use of PLUS II, 'decision rule' will refer to the planner's 'plan' for determining the use to which an individual land parcel (in this case a grid cell) should be allocated. For example, a planner wishing to allocate high quality agricultural land to agriculture might have a decision rule of the form "If CLI agricultural capability is less than four allocate the cell to agriculture". The decision rule may be much more complicated than this, and in certain cases the rule may be of the form "If the result of the operation 70.5 - .16 (CLI Agriculture Capability) plus .027 (pounds of nitrogen added/acre) is greater than 70.5 then allocate to agriculture".

A series of functions which will permit the planner to specify a decision rule, to prepare a new coverage, and to examine and display it have been designed and incorporated into PLUS II. Data may be recorded as either numbers (numeric data) or symbols (alphanumeric data). In discussions of the functions of PLUS II, it will be stated that some will work only on alphanumeric data, and others solely on numeric. Numerals will be treated as alphanumeric if they are included in an alphanumeric data set.

Functions Available in PLUS II

HELP - Allows listing of functions.
CREATE - Allows creation of a new coverage by entering data from terminal. This task is more onerous than one might expect, and should only be attempted if the coverage has a limited number of cells.
COVERAGES - Allows listing of the coverages available to PLUS II (especially useful after new coverages have been created).
DISPLAY - Allows displaying of a selected coverage for visual checking. Often it is necessary to display a coverage in separage pages because of limitations of the output device.
DELETE - Allows removal of a coverage from PLUS II when it is no longer needed.
TABULATE - Allows tabulation of cells in a coverage by type or value.
CROSSTAB - Allows cross-tabulation of two alphanumeric coverages.
OVERLAY - Allows combination of two alphanumeric coverages by assigning new symbols to each existing combination of old ones and producing a new coverage as a result.
DTAB - Allows tabulation of a coverage by distance from a point specified.
RECODE - Allows recoding of the values or symbols in a coverage.
POLYGON - Allows creation of a coverage in which the cells lying inside an input polygon will be assigned a specific character or number.
CONTIG - Allows search through a coverage to determine areas over or under a certain size (size constraint is input by the planner).
REGRESS - Allows determination of the degree of relationship between numeric coverages using a regression technique. Although sophisticated numerical analyses can be performed within PLUS II, they are usually best performed by program packages operated outside the PLUS system.
COMBINE - Allows algebraic combination of two numeric coverages using a wide range of arithmetic operations.
STOP - Allows normal exit from the PLUS II system.

Using PLUS II
The use of PLUS II can be as simple or as complicated as required. In the following examples, we will assume that the necessary coverages are available.

Problem 1
To assess the feasibility of building a commercial plant to process a certain crop which will grow only on land of CLI agricultural type 3 or better (for this example, let us assume that the plant is to produce sauerkraut).

a) TABULATE the agricultural coverage (AGD) to make sure that there is enough suitable agricultural land in the study area to justify a plant.

b) If there is enough land, RECODE the AGD coverage, assigning 'b' to all cells where AGD is 0 or 4 or greater, and 'A' to those cells which are 1, 2 or 3. Store the recorded coverage in ONE.

c) DISPLAY ONE to show locations of suitable cabbage land. From this display, eyeball a suitable plant location (one of the geographic location programs outside PLUS II could be used for a more scientific estimate of the optimal centre), then use the coordinates of

this location in step d.
d) DTAB coverage ONE to find the amounts of suitable agricultural land within given distance ranges from the plant location entered. If it is desirable to locate the plant in an established community, enter the coordinates of settlements in the study area in turn, choosing to locate in that which is most preferable.

Problem 2

To define all land within a planning district which would be suitable for zoning 'Recreation' in a regional plan. The data are CLI Agricultural Capability (AGD of which we now have a recoded file ONE), and CLI Recreation Capability (REC).

a) Identify land of low agricultural productivity (say AGD>3 and AGD = 0) and high in recreation capability (say REC<4) by using RECODE to assign the alphanumeric symbol 'b̸' (blank) to all ONE cells having a symbol of 'A', and 'H' to all cells having the symbol 'b̸', calling the resulting coverage TWO.
b) DELETE ONE (to gain storage space for a new coverage).
c) RECODE to assign the alphanumeric symbol 'b̸' to all REC cells having a value of 5 or more and 'R' to all others, calling the resulting coverage ONE.
d) OVERLAY coverages ONE and TWO, assigning the character 'b̸' to cells in which either ONE or TWO (or both) are 'b̸' and 'R' to all others, calling the resulting coverage THR.
e) DISPLAY coverage THR to identify the locations of cells with the required characteristics of low agricultural capability and high recreation capability. These will be coded 'R'.

Problem 3

To determine the characteristics of the land that might be inundated by a flood of a specified height.

a) DELETE ONE (to gain storage space for a new file).
b) Use function POLYGON to create a coverage containing the symbol 'F' inside the flood boundary and 'b̸' outside it. To do this, the planner must specify the coordinates of the polygon approximating the flood boundary. Store these data in ONE.
c) DISPLAY ONE to ensure that the polygon has been correctly defined.
D) CROSSTAB ONE and AGD to show the amount of the flooded area by agricultural class. Each of these areas could then be mapped by use of the OVERLAY function on coverages ONE and AGD.

Problem 4

To determine the relationship between depth to water table (SIG) and wheat yield (MCIC). This may be done by using the non-metric statistics produced by CROSSTAB, or by using the REGRESS function. In this case, having two numeric files, the latter would be used.

a) REGRESS MCIC on SIG, using zero as the missing value code for both coverages in case there are missing observations.

On the basis of the result, the planner might recommend the encouragement of either drainage or irrigation schemes.

Problem 5

Assume that the analysis of PLUS I data for a similar area adjacent to the area of study has indicated that the relationship between annual barley yield per hectare (Y), CLI agricultural class (X) and nitrogen added per hectare (Z) has been calculated to be Y = 70.5 - .16X plus .27Z. Calculate the expected yield for this area by using function COMBINE.

a) Ensure that there is a file free for the coverage being prepared.
b) Run function COMBINE, specifying X as the first input coverage, with a constant of 70.5, a weight of - .16 and an exponent of 1.0, specifying coverage Z as the second coverage with a constant of 0.0, a weight of .27 and an exponent of 1.0. The option for combination specified should be addition. The resulting coverage (Y) would be the predicted barley yield. By running COMBINE again using coverage Y with a constant of 0.0 and a weight and exponent of 1.0 and yet another coverage as the second input, the planner could build up a complex predictive function. It is probable, however, that complex operations would be more easily prepared outside PLUS II and input to the system when complete.
c) The new coverage Y may then be used as any other numeric coverage.

SUMMARY

The above examples illustrate some of the power and flexibility of PLUS II, by addressing typical land use planning questions. The ease and simplicity of operating the required functions should enable the planner to use the system with a minimum training period. The development of the logical skills necessary for efficient use of the system will take longer. These, however, are best developed in a practical setting and will be a logical outgrowth of system use.

PLUS is still under development and has not

been thoroughly tested yet. Although PLUS I has been used on both CDC and IBM machines, and PLUS II on IBM, PDP and Hewlett-Packard computers, minor problems will still arise as the system is used. System enhancement will be carried out as user's problems and requests become evident. The next step in the development of PLUS as a working system will be its use in a land use planning exercise. Negotiations to this end are presently being conducted by the Lands Directorate.

LAND USE INFORMATION SERIES

P.H. Beaubier, K.G. Taylor and G. McLean
Lands Directorate
Environment Canada
Ottawa, Ontario

AIM OF THE SERIES

The Northern Land Use Information Map Series, prepared by the Lands Directorate for the Arctic Land Use Research (ALUR) Program of the Department of Indian Affairs and Northern Development, aims to provide a convenient information base to assist in regional land use planning and in a managed approach to northern development and environmental protection. The maps integrate a wide range of data on renewable resources and related human activities at a scale of 1:250,000. Some of the information included on the maps requires specific data on specialized topics. For these units, the series relies on direct inputs by the Canadian Wildlife Service (CWS), the Fisheries and Marine Service (FMS) and by Canada Land Inventory (CLI) personnel. The project also relies on the cooperation and assistance of other federal government departments, the territorial governments, private research groups, and local residents of the Yukon Territory and the Northwest Territories.

MAP CONTENT

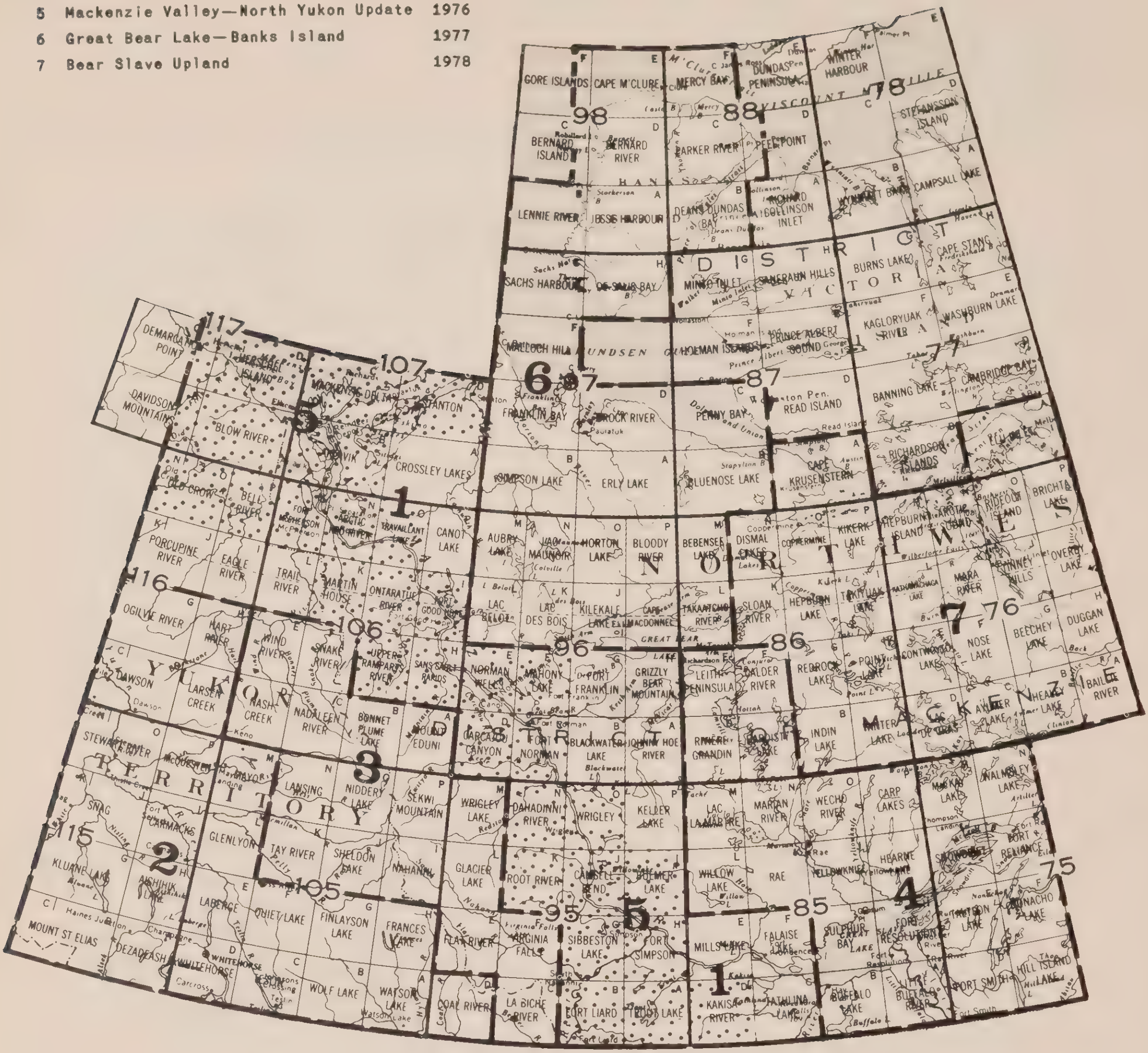
1) Wildlife: The delimitation, with coded legend notes, of important and critical wildlife areas. The information on wildlife resources, based on extensive CWS field surveys, includes comments on migration routes, waterfowl staging areas, nesting and calving areas, and winter range.
2) Fish Resources: Data provided by FMS include species composition and abundance, migration routes and spawning areas, and domestic, commercial and recreational fishing activity.
3) Recreation-Terrain Evaluation: The maps include an assessment by the Lands Directorate of general landscape aesthetics and detailed site analyses to identify areas of high recreation-tourism potential. The assessment is based on field surveys and evaluations of air photos and topographic maps using techniques developed by the CLI.
4) Socioeconomic and Cultural Data: The Lands Directorate collects data on socioeconomic and cultural features, including local hunting and trapping areas, big game hunting and outfitter areas, proposed International Biological Program reserves, Development Areas and Development Control Zones, transportation and communication systems, hydrometric and water quality stations, archaeological sites, historical sites, community information, climatic characteristics, break-up and freeze-up dates, campgrounds, sports fishing camps, fur take statistics, and forest resources.

PUBLICATION AND DISTRIBUTION

The integration of field information into final map form, compilation and drafting are undertaken by the Lands Directorate. Printed maps are distributed through the Canada Map Office, 615 Booth Street, Ottawa, K1A OE9. A sketch map of the Land Use Information maps published is shown on the next page. Further information on the map series may be obtained from:

Land Use Information Series
Lands Directorate
Environment Canada
Ottawa, Ontario
K1A OE7.

REGION	MAP SERIES	DATE PUBLISHED
1	Mackenzie Valley—North Yukon	1972
2	South and West Yukon	1973
3	Mackenzie and Selwyn Mountains	1974
4	Great Slave Lake Region	1975
5	Mackenzie Valley—North Yukon Update	1976
6	Great Bear Lake—Banks Island	1977
7	Bear Slave Upland	1978



The Department of Indian Affairs and Northern Development is responsible for the management of land and water resources in the Yukon and Northwest Territories and for ensuring that the benefits produced by the development of those resources are not obtained at the expense of extensive or unnecessary environmental degradation. In the fulfillment of these responsibilities, the Department relies, in part, on regulations issued under the authority of the *Territorial Lands Act* which came into effect November 15, 1971, and on the *Northern Inland Waters Act*, which came into effect on September 14, 1972. The Arctic Land Use Research (ALUR) Program was established by the Department to generate baseline information and to provide research support for the implementation and application of these regulations.

The Environmental Management Service of Environment Canada has undertaken the preparation of this series of land use information maps as part of the ALUR Program. The maps, at a scale of 1:250,000, summarize information on renewable resources and related human activities. They are an essential component of the information base that is being established to facilitate comprehensive regional planning and a managed approach to development and environmental protection.

Much of the basic data from which these maps were compiled was supplied by federal and territorial agencies. Northern residents also provided information on hunting, trapping, fishing, and recreation. All these contributions are appreciated and additional information from agencies and individuals will be gratefully received.

Requests for additional information on the series should be directed to:

Chief,
Water, Lands, Forests and Environment Division,
Northern Natural Resources and Environment Branch,
Department of Indian Affairs and Northern Development,
Ottawa, K1A 0H4.

or

Director,
Land Evaluation and Mapping Branch,
Lands Directorate,
Environmental Management Service,
Department of the Environment,
Ottawa, K1A 0H3.

DATA AVAILABLE FOR NORTHERN NEEDS FROM THE ATMOSPHERIC ENVIRONMENT SERVICE

G.A. McKay
Atmospheric Environment Service
Environment Canada
Downsview, Ontario

PART 1 — PUBLISHED DATA

Description	Sample Application	Selected Publication (see Part II)
1. Wind and related parameters		
- distribution frequency by direction for various speed catagories	townsite planning, recreation, pollution potential, forest fire potential	1
- extreme winds	structural design, town siting	1
- duration of light winds	pollution potential	3
- windchill	human comfort - recreation	2,3
- mesoscale variations in wind	townsite planning, pollution control	20
2. Temperature and related parameters		
- temperature normals and extremes	recreation, agriculture, building design, transportation	5,6
- mesoscale variations in temperature	townsite planning, agriculture	20
- growing degree-days	agriculture	9,18
- heating degree-days	building design, heating costs	8
- soil temperatures	foundation design, agriculture	10
- frost data	agriculture, roads	11
3. Precipitation and related parameters		
- average rain and snowfall, extreme values	sewer and storm drain design, highway planning, flood potential	5,6,7
- snowcover normals and extremes; variations with topography	flood potential, transportation	12,13,15,21
- snow transport (blowing snow)	transportation	16,17
4. Other parameters		
- sunshine	recreation, agriculture	6,14
- thunderstorms	forest fire potential	14
- fog and cloud	transportation - aviation, human comfort	17
- winds aloft, temperature inversion frequencies	pollution potential	3,19

PART 2 — PUBLICATIONS AVAILABLE FROM THE ATMOSPHERIC ENVIRONMENT SERVICE

1) Climatic Normals - Volume 5 Wind
2) Wind Chill in Canada
3) Climate of the Mackenzie Valley-Beaufort Sea
4) A Climatic Classification of the Northwest Territories for Recreation and Tourism
5) Temperature and Precipitation - the North
6) Atlas of Climatic Maps
7) Atlas of Rainfall Intensity
8) Heating Degree-Day Normals Below 65°F
9) Growing Degree-Day Normals Above 42°F
10) Soil Temperature Data
11) Frost Data 1941-1970
12) Snow Cover - Climatological Studies No. 3
*13) Snow Survey of the Mackenzie Valley
14) Climatic Normals - Volume 3, Sunshine, Cloud, Pressure and Thunderstorms
15) Winter Snowfall Averages and Extremes
16) A Study of Winds and Blowing Snow in the Canadian Arctic
17) Hourly Data Summaries (for individual sites)
18) Distribution of Growing Degree-Days in Can.
19) Upper Air Climate of Canada
*20) Mesoclimatic Study of Norman Wells
21) Snow Cover Data (issued yearly)

* From Information Canada

Except where noted, data are available from:

Meteorological Applications Branch
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario.
M3H 5T4.

PART 3 — COMPUTER PROCESSABLE FILES

CARD DOCUMENTATION

Card No. 1 - Hourly surface observations (up to 24/day)
Elements observed — ceiling height; weather and obstructions to vision; sea level pressure; dew point temperature; wind direction wind speed; station pressure; dry bulb temperature; wet bulb temperature; relative humidity; total opacity; total cloud amount; opacity; amount, type, height and total summation of each layer, visibility.

Card No. 2 - Surface synoptic data (up to 8/day)
Elements reported — cloud; wind direction and speed; visibility; present and past weather; sea level pressure; air temperature; dew point; pressure tendency and change; precipitation and snow amounts; depth of snow on ground; maximum and minimum temperatures.

Card No. 3 - Recording precipitation gauge data (1/day)
Data recorded — hourly, daily and monthly total precipitation amounts; intensities and dates on which they occurred and number of occurrences for specified amounts.

Card No. 4 - Summary for the climatological day (1/day)
Reported elements — maximum and minimum temperatures; maximum and minimum relative humidities; 6-hour amount of precipitation; 24-hour amount of rainfall, snowfall and total precipitation; snow depth; days with thunderstorm; freezing rain or drizzle; hail, fog or ice fog; smoke or haze; blowing dust or sand; blowing snow; wind speed equal to or greater than 32 mph and 39 mph; direction, speed and hour of peak wind gust.

Card No. 5 - Upper air standard pressure level data
Elements reported — station pressure; surface temperature; relative humidity; wind direction and speed at the time of release; height; temperature; relative humidity and wind direction and speed for each standard pressure surface.

Card No. 6 - Upper air standard pressure level data
Elements observed — surface wind data and wind data for specified standard levels to termination of ascent.

Card No. 7 - Radiosonde special data
Elements reported — cloud and weather conditions at time of observation; height and pressure of the lowest and highest freezing level; first and second tropopause data; maximum wind data.

Card No. 8 - Significant level data (upper air)
Elements reported — pressure, temperature, relative humidity and height of each significant level.

Card No. 9 - International marine meteorological data
Elements reported — country; data; octant; latitude and longitude; hour; total cloud; wind direction and speed; visibility; present weather; past weather; sea level pressure; air temperature; wet bulb temperature; clouds; sea temperature; direction, period and height of swell waves; ship number.

Card No. 10 - Hourly and daily total sunshine data
Sunshine amounts to nearest tenth of an hour.

Card No. 11 - Hourly and daily total solar radiation data
Radiation amounts in langleys and tenths.

Card No. 12 - Soil temperature data
Soil temperatures from specified depth and snow depth twice/day.

Card No. 13 - Evaporation pan data
Elements reported — water loss from pan; daily wind mileage; mean water temperature; mean air temperature; computed lake evaporation.

Card No. 14 - National air pollution data
Elements observed — temperature at 20' level; wind direction and speed at three different heights; temperature differences between levels; surface wind direction and speed; hourly precipitation; sulphur dioxide; coefficient of haze; ozone.

Card No. 15 - Surface wind data
Hourly wind speed and direction.

Card No. 16 - Break-up and freeze-up data
Dates of specified categories of break-up and freeze-up; maximum ice thickness.

Card No. 17 - Agrometeorological data
Elements observed — snowfall depth and water content; minimum temperature of grass thermometer; dry bulb; wet bulb; dew point; duration of sunshine; wind daily total mileage; maximum wind direction and speed; latent evaporation; wetting duration.

Card No. 18 - General upper air data
Surface synoptic data; recorded level data; termination altitude data; significant wind level data; computed count group.

Card No. 21 - Fischer-Porter precipitation gauge data - Precipitation amounts 4/hr.

STATION NAME	CARD NO.																		
YUKON	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	21
Aishihik A	.			.											.				
Anvil				.											.				
Beaver Creek				.											.				
Burwash A	.			.															
Carcross				.															
Carmacks			.	.															
Casino Creek				.															
Clinton Creek				.															
Dawson	.			.											.				
Dempster				.															
Drury Creek				.															
Elsa				.															
Faro				.															
Fort Selkirk			.	.						.			.						
Frances Lake	.			.						.			.		.				
Haines Junction			.	.						.		.	.		.		.		
Herschel Island	.			.															
Johnsons Crossing			.	.															
Kluane Lake				.						.									
Komakuk Beach	.			.						.					.				
Mayo A	.			.											.				
Ogilvie River				.															
Old Crow				.															
Parkin				.											.				
Ross River			.	.											.				
Shingle Point	.			.											.				
Snag A	.			.											.				
Stokes Point				.															
Swede Creek				.						.									
Swift River				.															
Teslin A	.		.	.											.				
Tuchitua				.															
Watson Lake A	.		.	.						.		.			.				
Whitehorse	.			.															
Whitehorse A	.		.	.	.	.	.	.		.					.			.	
Whitehorse Riverdale				.															
Wolf Creek				.															
N.W.T.																			
Aklavik	.			.	.	.	.	.		.	.				.			.	
Aklavik Radiosonde				.															
Alert	.			.	.	.	.	.		.	.				.			.	
Arctic Bay	.			.	.		.	.							.			.	
Atkinson Point				.															
Baker Creek				.															
Baker Lake	.			.	.	.	.	.		.	.	.			.			.	
Bathurst Inlet	.			.															
Bernard Harbour	.			.															
Bray Island				.															
Brevoort Island	.			.															
Broughton Island	.			.															
Broughton Village				.															
Byron Bay	.			.															
Cambridge Bay A	.		.	.	.	.	.	.		.	.				.			.	
Cape Dorset	.		.	.						.					.			.	

STATION NAME	CARD NO. (Continued)																		
N.W.T.	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	21
Cape Dyer A	.			.															
Cape Hooper	.			.															
Cape Parry A	.			.															
Cape Peel				.															
Cape Young	.			.															
Chesterfield	.			.											.				
Chesterfield Inlet	.			.															
Clifton Point				.															
Clinton Point	.			.															
Clyde	.			.	.	.	.	.		.					.			.	
Contwoyto Lake	.			.															
Coppermine	.			.	.	.	.	.		.					.			.	
Coral Harbour A	.			.	.	.	.	.		.	.				.			.	
Craig Harbour	.			.															
Dewar Lakes	.			.															
Dundas Harbour	.			.															
Durban Island				.															
Ekalugad Fiord				.															
Ennadai Lake	.			.											.				
Eskimo Point	.			.											.				
Eureka	.			.	.	.	.	.		.	.				.			.	
Fort Good Hope	.			.											.				
Fort Good Hope 2	.			.															
Fort Liard				.															
Fort McPherson	.			.															
Fort Norman	.			.															
Fort Providence	.			.											.				
Fort Reliance	.		.	.											.				
Fort Resolution A	.		.	.											.				
Fort Ross	.			.											.				
Fort Simpson	.			.						.	.				.				
Fort Simpson A	.		.	.											.				
Fort Simpson CDA				.						.		.					.		
Fort Smith A	.			.	.	.	.	.		.	.	.	.		.			.	
Frobisher Bay A	.			.	.	.	.	.		.	.							.	
Gladman Point	.			.															
Grise Fiord				.											.				
Hall Beach A	.			.	.	.	.	.			.							.	
Hat Island				.															
Hay River A	.		.	.											.				
Hay River Paradise Gdns				.															
Holman	.			.											.				
Horn River				.															
Horton River				.															
Igloolik															.				
Inuvik A	.		.	.	.	.	.	.		.	.				.			.	
Isachsen	.			.	.	.	.	.		.	.				.			.	
Jenny Lind Island	.			.											.				
Johnson Point	.			.															
Keith Bay				.															
Kingyouk Creek																			.
Kivitoo																			
Lady Franklin Point				.															
Lake Harbour	.			.															
Longstaff Bluff	.			.															
Mackar Inlet	.			.											.				
Matheson Point				.															
Mould Bay	.			.	.	.	.	.		.	.	.			.			.	

STATION NAME	CARD NO. (Continued)																		
N.W.T.	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	21
Nahanni Hot Springs																			•
Nicholson Peninsula				•															
Norman Wells A	•			•	•	•	•	•		•			•		•			•	
Nottingham Island	•			•											•				
Padloping Island	•			•															
Pangnirtung	•			•															
Pearce Point				•															
Pelly Bay	•			•															
Pond Inlet	•			•															
Port Burwell	•			•															
Port Radium	•			•											•				
Rea Point A	•			•											•				
Repulse Bay				•											•				
Resolute A	•			•	•	•	•	•		•	•	•	•		•			•	
Resolution Island	•			•											•				
Res'n Is C Warwick	•			•											•				
Ross Point	•			•											•				
Rowley Island	•			•															
Sachs Harbour	•			•	•	•	•	•		•	•				•			•	
Sans Sault Rapids				•															
Sarcpa Lake				•															
Shepherd Bay	•			•											•				
Simpson Lake				•															
Snare Rapids	•			•											•				
Snowdrift				•											•				
Spence Bay	•			•											•				
Sturt Point				•															
Tuktoyaktuk	•			•															
Tuktoyaktuk A				•											•				
Tundra Mine				•															
Tungsten				•															
Tununuk				•															
Virginia Falls																			•
West Baffin Island				•															
Wrigley A	•			•											•				
Yellowknife A	•		•	•						•			•		•				
Yellowknife Hydro				•															

ARCHAEOLOGICAL BASE DATA NEEDS IN CANADA'S NORTHLANDS

R. Wilmeth
Archaeological Survey of Canada
National Museums of Canada
Ashton Press Building
Bells Corners, Ontario

INTRODUCTION

During the past 50 years, since the days of the work of the late Diamond Jenness, archaeologists have shown considerable interest in the prehistory of northern Canada, particularly as the interior plateau of the Yukon and British Columbia, and the Mackenzie Valley were logical routes for the entry of the earliest population into the New World, and evidence for their presence might be expected to be found there. The majority of this work has been supported by the National Museums of Canada, with staff members working in the area including Diamond Jenness, D. Clark, B.C. Gordon, W.N. Irving, T.E. Lee, G.F. MacDonald, R.S. MacNeish, R. McGhee, R.E. Morlan, W.E. Taylor, Jr. and J.V. Wright. Through contracts, the National Museums of Canada have also supported the work of K.W. Ames, A.L. Bryan, J. Chism, J. Cinq-Mars, S.A. Crête, W.W. Fitzhugh, R. Gruhn, T.C. Losey, A. McCartney, J.F.V. Millar, S. Minni, W.C. Noble, P. Plumet, G.M. Rousselière, P. Severs, P. Schlederman and W. Workman.

However, a combination of factors (primarily individual research aims and problems of access to remote areas) have resulted in a non-random pattern of field work, in which some areas have been studied relatively intensively, while others have been largely ignored. This paper summarizes the major archaeological field work so far undertaken, the areas in which base data is lacking at present, and priorities for future work, both from the viewpoint of research aims and that of emergency situations, arising chiefly from increasing development in the north. The problems involved in filling in the gaps in our present survey will be considered.

REGIONAL SUMMARY

Area	Previous Research	Unexplored Areas	Priorities
A) Yukon Territory	Early work concentrated in two areas: from the Porcupine drainage north to the coast; and the southwest sector of the Territory. Investigators in the former area include: R.S. MacNeish on the Firth River and in the British Mountains; B.C. Gordon in the British Mountains and on the coast; and W.N. Irving, R.E. Morlan, J. Cinq-Mars and C.R. Harington in the vicinity of Old Crow and the Porcupine River. In the southwest, the major investigators have been: R.S. MacNeish along the Alaska Highway and in the Kluane Lake area; F. Johnson and H.M. Raup at Kluane Lake and in the Dezadeash valley; and J. Cook, W. Workman and R.E. Morlan in the Aishihik Lake area.	There has been no systematic work between the Porcupine drainage and the southwest Yukon, nor in the eastern part of the Territory.	a) Research - Of major interest is the unglaciated refugium extending from the north coast to the Yukon drainage. The significance is in terms of the possibility of finding evidence for very early entrants into the New World, which would have survived only in an unglaciated area. b) Salvage - The major concerns at present are with the continuing construction of the Dempster highway and with a number of power development projects at Aishihik Lake and elsewhere in the southwest. The National Museum of Man will direct field parties in these critical areas in 1974.
B) Northwest Territories	a) District of Mackenzie - Work carried out to date has concentrated on the western part of the district, including investigations by: R. McGhee and B.C. Gordon in the Mackenzie Delta; R.S. MacNeish, D. Clark, J. Cinq-Mars, J.F.V. Millar and B.C. Gordon in the Mackenzie Basin (in part associated with Mackenzie highway and pipeline corridor studies); J.V.F. Millar in the Ft. Liard area; W.C. Noble in the Great Slave Lake area and northward; R.S. MacNeish in the Great Bear Lake area; and R. McGhee on the Coppermine River. b) District of Keewatin - The major work here has been that of: B.C. Gordon on the Back River; J.V. Wright, E. Harp and B.C. Gordon on the Thelon; W.N. Irving and E. Harp in the southeast part of the District; A. McCartney and U. Linnamae at Chesterfield and Rankin Inlet; H. Collins on Southampton Island; and W.E. Taylor, Jr. on Mansell Island.	These include the area from Great Bear Lake north to Amundsen Gulf and from Horton Lake east to the Coppermine River; the Upper Back River as far as Beechey Lake; the area north of the Back River from Coronation Gulf to Repulse and Wager bays; and all of the south-east corner of the N.W.T. east of Great Slave Lake.	a) Research - Areas of greatest potential in terms of current research areas include: the area mentioned above north of Great Bear Lake; the south-east corner of the N.W.T.; a strip from Grinnell Peninsula south to Spence Bay; and Axel Heiberg Island. b) Salvage - Major concerns are: the Mackenzie Highway; the Mackenzie Valley Pipeline; the proposed hydro development at Kakisa Lake and Lac La Martre; the destruction of sites by whale-bone mining to support the native carving industry; oil and natural gas exploration activities; and problems resulting from erosion at certain points on the coast. The National Museum of Man is taking steps to cope with some of these problems.

REGIONAL SUMMARY (CONTINUED)

Area	Previous Research	Unexplored Areas	Priorities
	c) District of Franklin - Prior research activities include: W.E. Taylor, Jr., R. McGhee and B.C. Gordon on Victoria and Banks islands; B. Yorga from Spence Bay north into Boothia Peninsula; and M. Maxwell, P. Schledermann, G. Wenzel and G.M. Roussilière on Baffin Island.		
C) British Columbia	Only limited work has been done in the section of the province under consideration, and this has largely been restricted to surveys. G.F. MacDonald, K. Fladmark, P. Severs and N. Gessler have covered a good deal of the east half of the Queen Charlottes; the area of Ice Mountain and Telegraph Creek has been surveyed by B.C. Gordon, W.J. Workman and J. Smith; R.S. MacNeish has worked in the northeast corner along the Yukon border; K. Fladmark has excavated in the Prince George vicinity; R.S. MacNeish carried out a survey in the extreme northwest around Atlin and Teslin lakes; The Archaeological Sites Advisory Board has surveyed the Kitsumkalem and Nass drainage from Terrace to Aiyansh.	Except for the limited surveys outlined, the entire northern extension is unexplored, as well as the off-shore islands and the west coast of the Queen Charlottes.	a) Research - first priority would be given to survey of specific drainages, namely the Nass, Stikine, upper Skeena, and the Finley-Parsnip area. b) Salvage - major concerns at present are an extension of the B.C. Railway from Fort St. James to Dease Lake, and an extension of the C.N. Railway from Terrace to Ground Hog. The B.C. Archaeological Sites Advisory Board is working in these areas.
D) Alberta	Previous work is extremely limited, in number of projects and their scope. The most concentrated work has been that of R. Gruhn at Calling Lake. Additional work has been undertaken by J.V. Wright on the Peace River and at Lake Athabaska; T.C. Losey on the Athabaska River north of McMurray and at Cold Lake; and A.L. Bryan near Bonnyville.	With the exception of the work mentioned, the entire region is uninvestigated archaeologically.	a) Research - the Peace and Athabaska drainages would probably be given the first consideration. b) Salvage - except for the erosional damage to sites in at least one area, there is no major salvage problem, except for the possible passage through this district of the Mackenzie Valley pipeline.

REGIONAL SUMMARY (CONTINUED)

Area	Previous Research	Unexplored Areas	Priorities
E) Saskatchewan	Activities in this area have been minimal. J.V. Wright has surveyed and excavated around Lake Athabaska; S. Minni carried out salvage work at Black Lake; J. Brown has worked in the Lac La Ronge area; and P.G. Downes made surface collections at Reindeer Lake.	Except for the work cited, the entire region is an archaeological blank spot.	There are no specific priorities, except that all lakes have high potential. The Churchill Diversion project will have an impact on part of the area.
F) Manitoba	Earlier work is limited to J.V. Wright's investigations at Southern Indian Lake, God's Lake and Split Lake; the work of R. Nash in the extreme northeast of the province and in the Churchill drainage from Pukatawagan to the Saskatchewan border; and a survey of the Grass River area by W.M. Hlady.	This includes most of the region, except for the areas referred to at the left.	a) Research - surveys of all lake margins would have the highest priority. b) Salvage - the Churchill Diversion Project is the major problem at the present time. The Manitoba Govt. has funded several years of work in this area, under the direction of O. Mallory.
G) Ontario	No investigations have been carried out except for J.V. Wright's survey of the Attawapiskat River	The whole region remains to be investigated.	Special attention should be given to the lakes in the western half of the region, which still support sizeable native populations.
H) Quebec-Labrador	Although a sizeable number of investigations have been carried out, the geographical extent of this area makes the coverage relatively minimal. E.S. Rogers has surveyed the Mistassini drainage; W.E. Taylor, Jr., T.E. Lee and P. Plumet have worked in northern Ungava; J. Conrad and S.A. Crête worked at Indian House Lake; W.L. Fitzhugh carried out survey and excavation on the Labrador coast, especially at Hamilton Inlet; and J.V. Chism has conducted surveys in the area of the James Bay Hydro Project.	Most of this region is still unknown archaeologically.	These are difficult to assess at present. The region of the James Bay Hydro development clearly has high priority from the standpoint of salvage work.

DISCUSSION

Large areas remain to be studied archaeologically. Within these blank spots, there are specific priorities in terms of research needs and salvage emergency considerations. A number of problems, however, confront us in carrying out these objectives.

1) Centralization of Available Data

Information on site locations, reports of investigations, and other information is scattered. The National Museum of Man, in close cooperation with institutions across the country, is working on a National Archaeological Sites Inventory which will provide a central source, under constant revision, for data on archaeological site locations and related information. However, the process of accumulating this information in a central data bank is expensive and time-consuming.

2) Funding

Securing financial support is a problem facing all research scientists. Except for limited funds allotted directly to federal and provincial archaeological institutions, the only major source of financial support is the Canada Council. Increasing funding is fortunately becoming available to cope with situations requiring rescue or salvage efforts, but even these amounts are barely adequate.

3) Personnel

Given adequate financial support, the problem of finding qualified field workers arises. The number of trained graduate and undergraduate students is certainly increasing, but only a fraction of these have experience in northern archaeology or the problems of conducting field work in isolated and harsh conditions. Problems of obtaining qualified personnel are often greater than the problem of obtaining funds.

4) Logistics

Even with the developments of recent years, large areas of the north, including the northern section of the provinces, remain difficult of access. Funds which are adequate for work in southern Canada vanish rapidly in the north in view of higher expenses for food, for freighting, and the need for charter aircraft and helicopter service. As a result there is still a financial imperative to work in areas relatively easy of access, although these may not be the most crucial in terms of data needs

SUMMARY

Base data on archaeology are unavailable for large areas of northern Canada. The ideal solution would be the establishment of a long-term program of archaeological survey, concentrating in areas of research priority, to be followed by a selective excavation program. The ideal will certainly be greatly modified by emergency salvage requirements, by shortages of funds and trained personnel, and by the difficulties of operating in an isolated and often harsh environment.

DATA TO BE COLLECTED

Department of Northern Saskatchewan
Regina, Saskatchewan

The Department of Northern Saskatchewan, through a contract with the Institute for Northern Studies and Electrical Engineering Department of the University of Saskatchewan, is developing a geographical information storage and retrieval system. The information listed below will be included in the system:

Population:
- SHSP Master Registration File
- SHSP Family Records
- SHSP Beneficiary Records
- Live Birth Registration File
- Stillbirth Registration File
- Death Registration File
- Enumeration Area Summary Tape - DBS, 1961-66, 1971
- Band Lists

Education:
- Program and Enrollment Summary
- School Record
- Teacher Qualifications, Salary, and Experience
- Budget File

Health:
- Hospital Separation and Administration Statistical Record
- Patient History File
- Physician's File
- Treatment Centre File
- Patient Registration File
- Outpatient Contact File
- Tuberculosis Master Registration

Social Assistance:
- Decision Sheet File (SAP)

Fisheries:
- Fish Purchase Ticket File
- Fisherman File
- Lake File
- Sport Fishing Licence File

NOTE: These are being re-designed

The acquisition of data with respect to:
i) Government buildings and houses
ii) Sewer and water system
iii) Land records
iv) Soil tests
v) Water purity tests
vi) Water table tests and cores
vii) Power line locations, hook-ups and capacities
viii) Surveys
ix) Streets and roads
x) Community plans

The digitizing of information with respect to:
i) Minerals
ii) Forests
iii) Base topographical maps at 1:250,000

Phase II will involve the acquisition and system development of non-machine readable files as follows:

Education:
- Student Record
- Progress Report
- Principal's Monthly Attendance Report
- DIAND Education Files

Adult Education:
- Continuing Education File

Health:
- Public Health Nursing Reports
- Individual and Family Health Records
- Communicable Diseases
- Public Health Inspection
- Educational Psychologist Reports
- Medical Service Reports

The information listed below is also available for Northern Saskatchewan:
- CLI information (north to 55°N).
- Pilot Land Use Study Information (map sheets 73F,G,J,K).
- Churchill River Impact Study
- A variety of wildlife studies, eg Cumberland Delta area.
- Fur records.
- Forest inventory maintenance maps 4" = 1 mi (north to 57°).

Bibliographies include:

A Directory of Northern Research at the University of Saskatchewan, compiled by Linda Hayward, Institute for Northern Studies.

Annotated Bibliography on Eco-Biology in Northern Saskatchewan, compiled by the Institute for Northern Studies.

Selected Bibliography on Northern Saskatchewan, Institute for Northern Studies.

TOPOGRAPHIC MAPPING — 1974 STATUS

Surveys and Mapping Branch
Department of Energy, Mines and Resources
Ottawa, Ontario

Canada's mapping organizations face a tremendous task. The area to be covered is vast (about 8.7 million km^2) and the funds available for mapping are small. Although full topographic map coverage of the country is available at the 1:250,000 scale, full coverage at a scale of 1:50,000 will not be available before about 1995 if the revision of existing maps is to be maintained at an acceptable standard and if mapping funds remain at about the present level. About 45% of the total coverage has been completed at this scale — 5,720 sheets out of a total of 13,150. The breakdown of these sheets is: 4,651 full color maps; 731 monochrome maps; and 338 photomaps. The remaining unmapped areas at this scale include most of the Arctic Islands and large tracts of land east and west of Hudson Bay. Mapping of these areas is expensive and poses particular problems because of the difficulty of access and the low incidence of good weather for aerial photography.

New mapping of urban areas at the 1:25,000 scale has been temporarily suspended to allow a greater concentration of effort in the natural resource areas, but the existing 1:25,000 sheets will be kept up-to-date by revision. Some 780 sheets have been published to-date.

The fact that not all of Canada will be mapped at 1:50,000 before about 1995 should not cause great concern, provided that maps *are* available on time for those areas which will be subject to development. The Surveys and Mapping Branch has therefore directed considerable attention to the problem of *response-time* (ie the time which elapses between acceptance of the demand for a new map and its final production). Research has led to the development of two new processes which are based on the *quick response* concept. The more fundamental of these, the *Mapping Data Base*, consists of two distinct phases. During the first phase only the *framework*, consisting of relatively immutable elements of a map, is established. A geodetic control survey network is established over large blocks of about 38,400 km^2 and is followed by a sophisticated process of photogrammetric adjustment and manipulation resulting in a dense network of control points, fully adjusted and with precise values of latitude, longitude and altitude. This information is stored on tape in digital form and can be drawn automatically on stable film and plastic drawing material. In the second phase, the framework is retrieved from the storage system and processed directly or combined with recent photographs depicting the changing superficial characteristics of a particular area resulting in an up-to-date map of high quality. Application of this two-phase process will permit a substantial reduction in response time for the production of map manuscripts.

The conversion of a map manuscript into a printed colored map requires at least one year, unless an unusually high priority is given to the project. To reduce this delay, a second process has been instituted to speed up map production, namely the production of a monochrome version of the 1:50,000 line map to replace the colored map in isolated areas. No degradation in content or accuracy has been allowed in the process, but some loss in readability has inevitably resulted because of the absence of colours to differentiate topographical features (eg forest cover and swamp areas must be symbolized in black and white which obviously is not as apparent as green and blue). However, the users of the monochrome maps (engineers, prospectors, geologists, etc.) are usually trained map readers, and should therefore have no trouble with the new presentation. Approximate times required to produce 1:50,000 maps are shown below:

	Data Incomplete	From Framework Stored in Data Base
Colored line map	4 years	2 years
Monochrome map	3 years	1 year
Contoured photomap	3 years	1 year
Planimetric photomap	2 years	5 months

The program for the completion of the 1:50,000 series is difficult to formulate because of changes in demand. However, it may be described in general terms based on a realistic estimate of the funds likely to be made available for topographic mapping in the future and on the assumption that blanket coverage is desirable. The Surveys and Mapping Branch will continue to give priority to natural resource development areas and transportation routes. To provide complete coverage of geographic regions, a program to "fill in the blanks" will also continue.

Rough estimates of coverage are:

Completion of the Western Provinces except Manitoba east of 94° and a small area in northern British Columbia.	1980
Completion of all Provinces	1984
Completion of Canadian mainland	1990
Completion of all Canada	1995

PROJECT PLAN — INTEGRATED LANDSCAPE SURVEY OF POTENTIAL GAS PIPELINE ROUTES ON THE ARCTIC ISLANDS AND ADJOINING ARCTIC MAINLAND

H.J. Dirschl
Environmental-Social Program Northern Pipelines
Ottawa, Ontario

BACKGROUND

The land management goals of the federal government with respect to areas of relative wilderness are:

1) preserve the natural system or ensure that changes caused by resource development do not place undue stress on it;
2) achieve best use of land resources in the course of man's activities.

The recent discoveries of natural gas in several locations in the Arctic Islands and the subsequent formation of the Polar Gas Project, an industrial consortium interested in moving those gas reserves by pipeline to southern markets, make it urgent for the federal government to put itself in position to assess the probable environmental, social and resource-use implications of such a venture. Experience with the Mackenzie Valley pipeline program showed that a comprehensive research program has to be undertaken before the environmental, engineering, and social parameters are sufficiently understood to enable such an assessment. The complex interactions and interdependencies that exist within ecosystems should be emphasized by the study program. This is best achieved through close interdisciplinary and inter-agency cooperation in the planning, data collecting and interpretive phases of the work. Close integration not only ensures that all the important parameters are included in the program, but also has the added benefit of producing teams of experts who will be immediately available to the government to assess applications from industry in terms of the whole complex of environmental, social and resource use interactions.

Traditionally, scientists have worked independently within their own discipline and have generated separate products. Because the products have been generated independently, major inconsistencies may subsequently be found when it becomes necessary to relate various single-subject areas with each other, and therefore they may be less than satisfactory for decision-making.

Effective land use planning and management requires an objective means of making the following value ratings on a geographic basis:

1) Identification, within the total region, of areas of contrasting character or significance as components or the natural system;
2) Identification and classification of areas of differing values to man in carrying out land resource developments; and
3) Rating of each mapped area in terms of its reaction to use by man and the effect of such use on the natural system.

These geographic identifications and ratings can be best obtained as a derived product from a landscape classification and mapping system which integrates the relevant components of the natural system. Such a system of mapping must therefore incorporate, evaluate and portray the following components of the natural system:

1) The land surface (materials and landforms) and the processes which are active in it;
2) The relationships of water to the land (surface and ground water);
3) Vegetation distribution, its relationships to the landscape, and its reaction to changes in the land; and
4) Wildlife distribution and its relationships to vegetation, water and land.

The resultant integrated maps subsequently provide a base from which, in conjunction with supplementary data, interpretive maps can be derived to portray the following ratings and thus to provide a basis for the value ratings outlined above:

1) Land capability for wildlife (from integrated mapping system plus additional information from wildlife distribution and population surveys);
2) Esthetic considerations; outdoor recreational potential (from integrated mapping systems plus additional map and airphoto interpretation);
3) Land capability for other renewable resources (from integrated mapping system plus relevant resource data);

4) Land performance suitability for engineering development (from integrated mapping system plus geotechnical data); and
5) Terrain sensitivity to natural and man-made disturbance (from integrated mapping system plus case histories).

Although supplementary data are required to generate these derived maps, the nature of the final product is principally determined by input from the integrated mapping system. Interpretive maps derived from single-subject surveys yield acceptable value ratings in that narrow sense, but these ratings may be quite inconsistent when one topic is compared with another.

SCOPE

Within the context of the federal government's concerns regarding gas pipeline development in the Arctic, this project aims to produce an integrated landscape classification for those areas of the Arctic Islands and adjacent mainland through which trunk gas pipelines would likely be routed. That mapping system is to be adapted to the special environmental conditions of the Arctic and applicable to various governmental programs, including the interdepartmental pipeline concerns (in parallel to those for the Mackenzie Valley and Northern Yukon), and land management responsibilities of the Department of Indian Affairs and Northern Development, the wildlife management functions of the Canadian Wildlife Service (Environment Canada) and the Northwest Territories, and to northern development in general. The work will be based on the integrated landscape mapping system that is currently being developed according to experience gained in an interdisciplinary pilot study carried out in 1973 on Melville Island. Compatibility with the ecological (biophysical) land classification system will also be sought.

SPECIFIC OBJECTIVES

1) Through interdisciplinary cooperation by geologists/geomorphologists, pedologists, plant ecologists, and wildlife biologists, to undertake an integrated landscape classification project adapted to the terrain and vegetation conditions of the Arctic. The work will involve the properties and distribution of surface and near-surface materials, landforms and vegetation, as well as appropriate references to soils, ground ice, surface and ground water, active geomorphic processes, slope instability and other hazards. It will aim to differentiate, classify and map ecologically significant segments of the land surface to serve as a common vehicle for wildlife habitat classification and capability rating, terrain sensitivity rating, evaluation of the terrain's engineering performance, assessment of recreational potential and wilderness preservation requirements, and other evaluative classifications that may be required.
2) By employing this approach, to produce integrated landscape maps at a scale of 1:125,000 and detailed legends for the potential pipeline routes.
3) Based on the above maps and appropriate supplementary information, to produce interpretive maps and descriptions as listed above.

STUDY AREA

The extent and location of the study area is related to the potential route for a pipeline to transport natural gas from the Arctic Archipelago through the N.W.T. to southern Canada. The Polar Gas Project is examining a number of route alternatives; until the proposed routing is more clearly defined, an exact study area cannot be delineated. Field work will initially concentrate on segments of the region where distribution of known gas fields and geographic constraints clearly indicate final route selection (eg Melville Island, Bathurst Island and Boothia Peninsula). Areas where there is considerable uncertainty regarding final route selection will be deferred until the final year of the survey (eg eastern Keewatin).

PRELIMINARY RESEARCH (1973-74)

A pilot study to develop a classification system for an integrated landscape survey has been underway since June 1973. This work, funded out of regular departmental budgets, has involved interdisciplinary cooperation by geologists/geomorphologists (Geological Survey of Canada, Energy, Mines and Resources), plant ecologists and air photo interpreters (Canadian Forestry Service, Environment Canada) and wildlife biologists (Canadian Wildlife Service, Environment Canada). Additional input has been received from pedologists (Soil Research Institute, Agriculture Canada) and land classification specialists (Lands Directorate, Environment Canada). Field research was carried out during July and August 1973 throughout most of the eastern part of Melville Island, N.W.T. Prior geological reconnaissance by the Geological Survey of Canada in 1971 and 1972 provided the starting point for the integrated approach used in the 1973 field season.

Interdisciplinary teamwork has continued since the end of the field season, and is expected to result by spring 1974 in:

1) the development of an integrated landscape classification system adapted to arctic environments;
2) manuscript maps, based on this system, for eastern Melville Island;
3) an expanded legend and/or map overlays to indicate for each landscape unit the significant environmental parameters (eg geomorphic features, soils, vegetation, ground ice) and to rate these units in terms of relative terrain tolerance to disturbance, trafficability, engineering performance, and habitat capability for major wildlife groups (including caribou, muskoxen and waterfowl); and
4) a comprehensive summary report on the pilot study.

RESEARCH IN 1974-75

Investigation will encompass areas potentially traversed by pipelines on Bathurst, Byam Martin and Cornwallis islands. Because of its interdepartmental nature, the project will be coordinated by the Senior Environmental Analyst of the Environmental-Social Program Northern Pipelines as well as a steering committee consisting of senior technical representatives of: Terrain Sciences Division Geological Survey of Canada (Energy, Mines and Resources); Forest Management Institute, Canadian Forestry Service (Environment Canada); Eastern Region, Canadian Wildlife Service (Environment Canada); Water, Forest & Lands Division, (Indian Affairs and Northern Development); and Lands Directorate (Environment Canada). Direct supervision in the field will be through a party chief, appointed from among the research officers assigned to the project. Basic office facilities for the team will be arranged by the Environmental-Social Program Northern Pipelines, but any necessary specialized equipment will be the responsibility of the cooperating agencies. Field camp facilities, radios, food, fuels, air transport (helicopters and fixed wing aircraft charters) and ground transport (Honda tricycles) will be the responsibility of GSC.

Staff expertise will be made available as follows:

Geology/Geomorphology	- Terrain Sciences Division, GSC (EMR)
Pedology	- Soil Research Institute (CDA)
Plant Ecology	- Forest Management Institute, CFS (DOE)
Wildlife Ecology (Mammalogy and Ornithology)	- Eastern Region, CWS (DOE)
Soil Hydrology	- Inland Waters Directorate (DOE)
Supporting 70 mm Photography	- Eastern Region, CWS (DOE)
Systematic Data Storage Processing and Retrieval	- Lands Directorate (DOE)

PHASING BEYOND 1974-75

To complete the survey within the anticipated life of the Arctic Islands Program, it will be necessary to operate two field parties each in 1975-76 and 1976-77. Areas to be covered are now visualized as follows (subject to revision as the potential pipeline routes become more clearly defined).

Fiscal Year 1975-76

Team 1: King Christian Island, Ellef Ringnes Island, Cornwall Island, Grennel Peninsula.
Team 2: Boothia Peninsula - Repulse Bay area.

Fiscal Year 1976-77

Team 1: Somerset Island - Prince of Wales Island.
Team 2: Eastern Keewatin or Southampton, Coats and Mansel islands.

NORTHERN CANADA SPECIAL PROJECTS AND NEW NETWORK STATIONS

Inland Water Directorate
Environment Canada
Ottawa, Ontario

* - Existing network stations
A, B, H - Parameters measured as outlined in index
P, Q, BM, M, SM - Sampling frequency as outlined in index
\+ - Parameters measured include:
Aluminum, antimony, arsenic dissolved, barium, cadminm, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, silver, strontium, vanadium, zinc, and thallium (unless otherwise indicated, all metals are extractable). Occasionally - pH, temperature, specific conductance and pesticides.

British Columbia

Data Processing Number	Station	Latitude Longitude	Sampling Frequency	Period of Record	Parameters Measured
40BC07FC0002	Fort St. John Pumphouse Finished Water Supply Source Charlie Lake Fort St. John, B.C.	-	P	1973-	NTA
Alberta Heavy Metals					
00AL07FD0004	Clear River near Bear Canyon	56° 18, 20" 119° 40' 50"	X = 1	1972 (One card)	+
00AL07FD0005	Hines Creek near Fairview	50° 04' 5"	P	1972-	+
00AL07HA0001	Peace River at Peace River	56° 14' 41" 117° 18' 46"			
00AL07HA0007	Heart River near Nampa	56° 3' 117° 7'	X = 1	1973	+
00AL07HA0008	Whitemud River near Dixonville	56° 30' 40" 117° 39' 32"	P	1972-	+
00AL07HC0006	Notikewin River at Manning	56° 55' 117° 37'	P	1972- (One card)	+
00AL07HC0007	Hotchkiss River at Hotchkiss	59° 03' 116° 34'	P	1972- (One card)	+
*00AL07HF0001	Peace River at Fort Vermilion	58° 23' 15"	P	1971-	+
00AL07HF0002	Keg River at Keg River	57° 44' 40" 117° 37' 40"		1972- (One card)	+

Alberta - cont'd.

Data Processing Number	Station	Latitude Longitude	Sampling Frequency	Period of Record	Parameters Measured
00AL07JD0003	Bear River south of Fort Vermilion	58° 15' 115° 49'	X = 2	1972	+
00AL07JF0001	Ponton River at Rocky Lane	58° 32' 116° 22'	P	1972	+
00AL07JF0003	Caribou River east of Rocky Lane	58° 30' 115° 54'	P	1972- (One card)	+
00AL070B0001	Steen River near Steen River	59° 36' 117° 12'	P	1972- (One card)	+
00AL070B0002	Hay River near Meander River		P	1972-	+
00AL070B0003	Hay River at Indian Cabins	59° 53'	X = 1	1973 (One card)	+
00AL070C0001	Chinchaga River West of Paddle Prairie	57° 50' 117° 50'	X = 1	1973 (One card)	+
00BC07FD0002	Peace River at Hwy. #97		P	1971 (One card)	+
00BC07FD0005	Peace River at Clayhurst Ferry (near B.C./Alta. Border)	56° 07' 45" 120° 03' 20"	P	1972- (One card)	+
Saskatchewan River Headwaters					
00AL07CD0002	Clearwater River at Upper Wingham	56° 42' 0" 111° 20' 0"	X = 2	1973	A
Saskatchewan Trace Metals					
*00SA06BD0001	Haultain River above Junction of Churchill River	56° 14' 40" 106° 33' 45"	P	1972 (One card '73)	B & Trace Metals
00SA06CE0001	Foster River above Churchill River		Q	1972-	B & Trace & Pest.
00SA06DC0001	Wathaman River below Wathaman Lake	57° 05' 20" 103° 42' 40"	P	1972- (One card '73)	B & Trace & Pest.
00SA07LC0001	Fond-du-Lac River at outlet of Black Lake	59° 9' 0" 105° 32' 30"	P	1972-	B & Trace & Pest.
00SA07LD0001	Cree River at outlet of Wapata Lake	59° 46' 00" 105° 47' 30"	BM	1972-	B & Trace & Pest.
00SA07MB0001	McFarlane River at outlet of Davy Lake	58° 57' 108° 10'	BM	1972-	B & Trace
00SA06DA0001	Wollaston Lake at Ross Channel		Q	1972-	B & Trace
01SA07LB0001	Waterbury Lake at Crew Cabin	58° 13' 104° 13'			
01SA07MC0001	Lake Athabasca near Cracking Stone Point	59° 22' 55" 108° 42' 50"	BM	1972-	B & Trace & Pest.
Manitoba Heavy Metals and Pesticides					
00MA06DA0001	Cochrane River near Brochet	58° 0' 0" 101° 23' 45"	P	1972-	B & Trace & Pest.

Manitoba - cont'd.

Data Processing Number	Station	Latitude Longitude	Sampling Frequency	Period of Record	Parameters Measured
*00MA06EA0001	Churchill River above Granville Falls		P	1972-	B & Trace & Pest.
00MA06EB0001	Barrington River West of Opachuanau Lake	56° 46' 0" 99° 55' 0"	P	1972-	B & Trace & Pest.
00MA06EB0002	Churchill River near Leaf Rapids	56° 30' 0"	X = 2	1972	B & Trace
*00MA06FA0001	Gauce River above Thorsteinson Lake		P	1972-	B & Trace & Pest.
*00MA06FB0001	Churchill River below Fiddler Lake	57° 15' 0" 96° 46' 30"	P	1972-	B & Trace & Pest.
*00MA06FC0001	Little Churchill River above Recluse Lake	56° 54' 0" 95° 48' 0"	X = 1	1972	Trace Metals & Pest.
00MA06FD0002	Churchill River at Red Head Rapids		P	1972-	B & Trace & Pest.
00MA06GA0001	South Seal River above Fox Lake	58° 8' 35" 98° 13' 40"	X = 2	1972	B & Trace Metals
00MA06GB0001	North Seal River below Stoney Lake		X = 2	1972	B & Trace Metals
00MA06GD0001	Seal River below Great Island	58° 53' 30" 96° 16' 31"	X = 2	1972	B & Trace & Pest.
Northwest Territories National Network (New)					
00NW07PA0002	Buffalo River at Hwy. No. 5	60° 42' 45"/ 114° 55' 0"	P	1972-	A
00NW07UC0001	Kakisa River at outlet of Kakisa Lake	60° 55' 0"/ 117° 25' 0"/	P	1971-	A
00NW10EA0004	Flat River near mouth	61° 32' 0"/ 125° 24' 20"	P	1973-	A
00NW10PC0001	Coppermine River near mouth at Coppermine		M	1960-	A
Mackenzie Pipeline					
00NW07NB0001	Salt River at Highway No. 5 Bridge	60° 02'/ 112° 22'	P	1972	A & Trace Metals
*00NW10EB0001	South Nahanni River above Virginia Falls	61° 38' 0"/ 125° 48' 0"	P	1973-	A
00NW10ED0002	Liard River at Fort Simpson		BM	1973-	A & Trace Metals
00NW10ED0004	South Nahanni River at Nahanni Butte	61° 2' 30"/ 123° 24' 0"	M	1972-	A & Trace Metals
00NW10ED0005	Liard River approx. 8½ miles below Fort Liard	60° 19' 0"/ 123° 22' 0"	M	1972-	A & Trace Metals
00NW10FA0002	Trout River approx. 2 miles from mouth	61° 17' 0"/ 119° 51' 0"	SM	1972-	A & Trace Metals
00NW10FA0003	Trout River at Fort Simpson Highway		M	1973-	A & Trace Metals

Northwest Territories - Cont'd

Mackenzie Pipeline Data Processing Number	Station	Latitude Longitude	Sampling Frequency	Period of Record	Parameters Measured
00NW10FB0002	Horn River near the mouth	61° 32' 0"/ 117° 57' 30"	BM	1972-	A & Trace Metals
*00NW10GC0001	Mackenzie River near Fort Simpson	61° 52'/ 121° 10'	M	1972-	A & Trace Metals
00NW10GD0001	North Nahanni River approx. 5 miles from mouth	60° 10' 30"/ 123° 23' 0"	M	1972-	A & Trace Metals
00NW10HA0001	Keele River approx. 4 miles from mouth	64° 23' 15"/ 124° 53' 0"	M	1972-	A & Trace Metals
00NW10HB0004	Redstone River at mouth	64° 16' 0"/ 124° 34' 30"	M	1972-	A & Trace Metals
00NW10HC0001	Mackenzie River near Wrigley	63° 16' 0"/ 123° 36' 0"	M	1972-	A & Trace Metals
00NW10HC0005	Blackwater River at mouth	63° 57' 0"/ 124° 09' 0"	M	1972-	A & Trace Metals
*00NW10JC0002	Great Bear River at mouth near Ft. Norman	64° 55' 0"/ 125° 35' 0"	M	1972-	A & Trace Metals
00NW10KA0002	Mackenzie River approx. 14.5 miles above Norman Wells (Southeast of Ten Mile Island)	65° 10' 0"/ 126° 25' 0"	M	1972-	A & Trace Metals
00NW10KC0002	Mountain River approx. 3 miles from mouth	65° 40' 0"/ 128° 54' 0"	M	1972	A & Trace Metals
00NW10KD0001	Ramparts River approx. 2½ miles from mouth	66° 10' 0"/ 129° 06' 30"	M	1972	A & Trace Metals
00NW10LA0003	Mackenzie River approx. 3/4 of a mile upstream from IHD station at Arctic Red River	67° 27' 30"/ 133° 42' 0"	M	1972	A & Trace Metals
00NW10LA0004	Arctic Red River approx. 1½ from mouth	67° 26' 0"/ 133° 46' 0"	M	1972	A & Trace Metals
00NW10LB0002	Mackenzie River approx. 2½ miles above Fort Good Hope	66° 14' 30"/ 128° 43' 0"	M	1972	A & Trace Metals
00NW10LD0002	Hare Indian River near the mouth	66° 18'/ 128° 34'	M	1972	A & Trace Metals
00NW10MC0002	Peel River at Fort McPherson	67° 26' 0"/ 134° 53' 30"	M	1972	A & Trace Metals
Mines					
10NW07PA0001	Well near mill site, Pine Point Mines, Pine Point Townsite		P	1966-70	A
22NW07PA0001	Property effluent, below tailings pond, culvert at north end of tailings pond, Pine Point Mines Ltd.		P	1970	H

Northwest Territories - Cont'd.
Mines

Data Processing Number	Station	Latitude Longitude	Sampling Frequency	Period of Record	Parameters Measured
22NW07PA0002	Tailings pond dam effluent on muskeg flat; N.W. of tailings pond lease area, Pine Point Mines		P	1969-70	H
22NW07PA0003	Pit effluent; mine water at southeast corner of tailings pond in the pit water discharge ditch, Pine Point Mines		P	1969-70	H
22NW07PA0004	Mill effluent; Pine Point Mines		P	1970	H
22NW07SB0001	Mill effluent; Giant Yellowknife Mines		P	1970-72	H
22NW07SB0002	Thickener discharge into Baker Creek (opposite the mill); Giant Yellowknife Mines		P	1968-71	H
22NW07SB0004	Mine water discharge from "C" shaft; before entry into Baker Creek		P	1968-72	H
22NW07SB0005	Tailings pond effluent below "B3" Area; Giant Yellowknife Mines		P	1970-72	H
22NW10JA0001	Tailings pond effluent at outfall line; Terra Mine		P	1970-72	H
22NW10JA0002	Tailings effluent from mill at outfall; Echo Bay Mine		P	1970-71	H
22NW10JA0003	Mine water effluent from No. 3 ADIT; Echo Bay Mine		P	1969-72	H
Federal Fisheries					
00NW07SB0001	Yellowknife River at mouth		P	1971-	H
00NW10ED0003	Liard River at Nahanni Butte, 1.5 miles from junction with South Nahanni River		P	1971-	H & Trace Metals
00NW10KC0001	Mountain River at mouth	65° 42'/ 128° 50'	P	1971-	H
Yukon Territory DIAND Yukon Mines					
00YT09AB0004	Whitehorse Copper Mines discharge into Crater Lake from under road	60° 38' 31"/ 135° 01/ 54"	M	1973-	A
00YT09AB0005	Creek Draining Crater Lake	60° 38' 35"/ 135° 01' 57"	M	1973	A

Yukon Territory - cont'd.
DIAND Yukon Mines

Data Processing Number	Station	Latitude Longitude	Sampling Frequency	Period of Record	Parameters Measured
00YT09BC0006	Rose Creek below Anvil Mines tailings pond near airstrip; Faro	62° 21' 41"/ 133° 25' 38"	M	1973-	A
00YT09BC0007	Rose Creek at inflo into Anvil Mines re-servoir; Faro	62° 19' 33"/ 133° 21' 0"	P	1973-	A
*00YT09BC0008	Pelly River below Vangarda Creek	63° 13' 20"/ 133° 22' 40"	P	1973-	A
00YT09CA0001	Nickel Creek above Hudson Yukon Mine Water outfall	61° 27' 8"/ 139° 30' 56"	M	1973-	H
00YT09CA0002	Quill Creek below confluence with Nickel Creek, approx. 4 miles west of Hudson Yukon Mine Mill	61° 27' 28"/ 139° 27' 31"	P	1973-	A
00YT09CA0003	Quill Creek above confluence with Nickel Creek	61° 26' 57"/ 139° 28' 28"	M	1973-	A
00YT09CA0004	Quill Creek below Hudson Yukon Mine tailings pond	61° 30' 17"/ 139° 19' 26"	P	1973-	H
*00YT09CD0001	Yukon River above White River	63° 08' 59"/ 139° 33' 10"	P	1973-	A
*00YT09DD0006	Stewart River at mouth	63° 16' 55"/ 139° 14' 56"	P	1972-	A
22YT09AB0001	Whitehorse Copper Mines tailings pond decant entering a stream flowing into Crater Lake	60° 38' 33"/ 135° 2' 48"	P	1969-	H
22YT09AB0002	Seepage from Whitehorse Copper Mines tailings pond (near location of old middle decant)	60° 38' 54"/ 135° 03' 0"	P	1970-	H
22YT09AB0003	Seepage from Whitehorse Copper Mines tailings pond (near location of old far decant)	60° 38' 50"/ 135° 3' 34"	P	1969-	H
22YT09BC0001	Effluent from Anvil tailings pond, Faro	62° 20' 22"/ 133° 23' 37"	M	1973-	A
22YT09BC0002	Rose Creek beside Anvil Mines tailings pond (suspected seepage)	62° 20' 24"/ 133° 24' 8"	M	1973-	H
22YT09CA0001	Hudson-Yukon Mine tailings pond decant flowing into Quill Creek	61° 29' 57"/ 139° 19' 57"	SM	1973-	H
22YT09CA0002	Hudson-Yukon Mine Water outfall at Nickel Creek	61° 27' 22"/ 139° 30' 14"	SM	1973-	H

Yukon Territory - cont'd.
DIAND Yukon Mines

Data Processing Number	Station	Latitude Longitude	Sampling Frequency	Period of Record	Parameters Measured
22YT09DD0001	United Keno Hill Mines mill tailings effluent, Elsa	63° 54' 50"/ 135° 30' 0"	P	1970-	H
22YT09DD0002	United Keno Hill Mines tailings pond effluent at "near decant tower" approx. 2 miles from Elsa	63° 55' 13"/ 135° 30' 35"	P	1970-	H
22YT09DD0003	United Keno Hill Mines tailing pond effluent at far decant tower approx. 2 miles from Elsa	63° 55' 14"/ 135° 30' 35"	P	1969-	H
Kluane Park Water Quality					
00YT08AA0001	Cottonwood Creek	60° 30'/ 137° 39'	P	1973-	A
00YT08AA0002	Marsh Creek at Campsite	60° 30'/ 137° 39'	P	1973-	A
00YT08AA0003	Victoria Creek	60° 31'/ 137° 26'	P	1973-	A
00YT08AA0004	Duck Creek	60° 32'/ 137° 26'	P	1973-	A
00YT08AA0005	Clear Creek	60° 32'/ 137° 22'	P	1973-	A
00YT08AA0006	Goat Creek	60° 33'/ 137° 20'	P	1973-	A
00YT08AB0001	Climbing Creek	60° 6'/ 137° 34'	P	1973-	A
00YT08AB0002	Mush Creek	60° 18'/ 137° 28'	P	1973-	A
00YT08AB0003	Bear Creek	60° 19'/ 137° 30'	P	1973-	A
00YT08AB0004	Plum Creek	60° 15'/ 137° 37'	P	1973-	A
00YT08AB0005	Shaft Creek	60° 18'/ 137° 33'	P	1973-	A
00YT08AB0006	Field Creek	60° 12'/ 137° 39'	P	1973-	A
00YT08AC0001	Hiking Creek	60° 6'/ 137° 25'	P	1973-	A
01YT08AA0001	Sockeye Lake	60° 30'/ 127° 38'	P	1973-	A
01YT08AA0002	Upper Kathleen Lake	60° 32'/ 137° 30'	P	1973-	A
01YT08AA0003	Lower Kathleen Lake	60° 34'/ 137° 18'	P	1973-	A
01YT08AB0001	Mush Lake	60° 18'/ 137° 27'	P	1973-	A

Kluane Park Water Quality - cont'd.

Data Processing Number	Station	Latitude Longitude	Sampling Frequency	Period of Record	Parameters Measured
01YT08AB0002	Bates Lake		P	1973-	A
01YT08AC0001	Onion Lake	60° 6'/ 137° 25'	P	1973-	A

LIST OF PARTICIPANTS (Addresses, where known, as of April 1979)

Babbage, G.
Surveys & Mapping Branch
615 Booth Street
Department of Energy, Mines & Resources
Ottawa, Ontario K1A 0E8.

Baker, W.M.
62 Sloley Road
Scarborough, Ontario M1M 1C8.

Beanlands, G.
Lands Directorate
Environment Canada
P.O. Box 365
Halifax, Nova Scotia B3J 2P8.

Beanlands, K.J.S.
Assistant Deputy Minister
Lands Branch
Department of Forestry and Agriculture
Confederation Building
St. John's, Newfoundland A1C 5TS.

Beaubier, H.
Regional Manager, Land Resources
Indian Affairs and Northern Devel.
200 Range Road
Whitehorse
Yukon Territory, Y1A 3A4

Bélair, J.L.
Direction régionale des terres
Environnement Canada
1080 Route du Vallon
Ste-Foy, Québec G1V 4C7.

Blower, D.
British Columbia Fish and Wildlife Branch
Parliament Buildings
Victoria, British Columbia.

Borys, A.E.
Senior Land Use Planner
Planning Branch
Department of Renewable Resources and Transportation
1495 James Street
Winnipeg, Manitoba R3H 0W9.

Boydell, A.N.
Resource Analysis Branch
Environment and Land Use Committee Secretariat
Parliament Buildings
Victoria, British Columbia V8V 1X4.

Boyle, A.R.
Department of Northern Saskatchewan
Saskatoon, Saskatchewan.

Brack, D.
Inland Waters Directorate
Environmental Management Service
P.O. Box 5111
Bedford, Nova Scotia.

Brown, C.S. (Ret.)
Lands Directorate
Environment Canada
Ottawa, Ontario K1A 0E7.

Burgar, R.J.
Land Use Co-ordination Branch
Division of Lands
Ontario Ministry of Natural Resources
Whitney Block, Room 1411
Queen's Park
Toronto, Ontario M7A 1X1.

Clark, J.S.
Soil Research Institute
Agriculture Canada
K.W. Neatby Building
Ottawa, Ontario K1A 0C6.

Cooke, L.J.
Alberta Department of the Environment
Room 100, 10040 - 104 Street
Edmonton, Alberta.

Coombs, D.B. (Ret.)
Lands Directorate
Environment Canada
Ottawa, Ontario K1A 0E7.

Day, J.H.
Soil Research Institute
Central Experimental Farm
Agriculture Canada
Ottawa, Ontario K1A 0C5.

Dirschl, H.J.
Kenya Rangeland Ecological Monitoring Unit
P.O. Box 47146
Nairobi, Kenya.

Duffy, P.J.B.
Policy, Planning & Evaluation Directorate
Environment Canada
Ottawa, Ontario K1A 0H3.

Freeman, N.G.
Canada Centre for Inland Waters
Environment Canada
Burlington, Ontario.

Fulton, R.J.
Terrain Sciences Division
Geological Survey of Canada
Department of Energy, Mines & Resources
601 Booth Street
Ottawa, Ontario K1A 0G1.

Gerardin, V.
Direction régionale des terres
Environnement Canada
1080 Route du Vallon
C.P. 2800
Ste-Foy, Québec G1V 4C7.

Gimbarzevsky, P.
Forest Management Institute
Environment Canada
396 Cooper Street, 2nd Floor
Ottawa, Ontario K1A 0E7.

Henderson, W.
Policy, Planning and Research Branch
Department of Indian & Northern Affairs
Ottawa, Ontario K1A 0H4.

Hnatiuk, J.
Saskatchewan Department of Natural Resources
Government Administration Building
Regina, Saskatchewan.

Jones, F.
Structural Accounts Branch
Statistics Canada
Coats Building, 25th Floor
Ottawa, Ontario K1A 0T6.

Jurdant, M.
Direction régionale des terres
Environnement Canada
1080 Route du Vallon
C.P. 2800
St-Foy, Québec G1V 4C7.

Lavallée, L.
Information and Data System Branch
Ministry of State for Urban Affairs
355 River Road
Ottawa, Ontario K1A 0P6.

Lavkulich, L.M.
Department of Soil Science
University of British Columbia
Vancouver, British Columbia V6T 1W5.

Lebuis, J.
Quebec Department of Natural Resources
Quebec City, Quebec.

Lee, G.O.
Lands Directorate
Environment Canada
20th Floor, Place Vincent Massey
Ottawa, Ontario K1A 0E7.

Lemieux, G.
Office de Planification et de Développement du Québec
Hôtel du Gouvernement
Edifice E
1050 St-Augustin, Québec G1R 4Z5.

Lindsay, J.D.
Alberta Research
Edmonton, Alberta.

Luckhurst, A.J.
Environment and Land Use Committee Secretariat
Province of British Columbia
Victoria, British Columbia.

Luke, G.P.
Resources Branch
Department of Public Works
Sir Charles Tupper Building
Ottawa, Ontario K1A 0M2.

Lush, D.L.
Beak Consultants Limited
6870 Goreway Drive
Mississauga, Ontario L4U 1L9.

Marsh, R.D.
Resource Analysis Branch
ELUC Secretariat
Province of British Columbia
Box 610
Smithers, British Columbia.

McCormack, R.J.
Lands Directorate
Environment Canada
20th Floor, Place Vincent Massey
Ottawa, Ontario K1A 0E7.

McKay, G.A.
Applications and Consultation Division
Atmospheric Environment Service
Environment Canada
4905 Dufferin Street
Downsview, Ontario M3H 5T4.

McKay, M.C.
Department of Northern Affairs
Province of Manitoba
500 - 213 Notre Dame Street
Winnipeg, Manitoba.

McMahon, R.
Planning, Research & Executive Council
Regina, Saskatchewan.

McQuillan, A.K.
Canada Centre for Remote Sensing
Department of Energy, Mines & Resources
2464 Sheffield Road
Ottawa, Ontario.

Meisner, R.M.K.
Resource Evaluation and Planning Division
Energy and Natural Resources
319 Natural Resources Building
9833 - 109 Street
Edmonton, Alberta T5K 2E1.

Morin, D.C.
Beak Consultants Limited
6870 Goreway Drive
Mississauga, Ontario L4U 1L9.

Munn, L.C.
Lands Directorate
Environment Canada
20th Floor, Place Vincent Massey
Ottawa, Ontario K1A OE7.

O'Donnell, J.H.
Surveys and Mapping Branch
Department of Energy, Mines & Resources
Ottawa, Ontario K1A OE8.

Pettapiece, W.W.
Alberta Institute of Pedology
Soil Survey
Agriculture Canada
University of Alberta
Edmonton, Alberta T6G 2E3.

Pierce, T.W.
Lands Directorate
Environment Canada
20th Floor, Place Vincent Massey
Ottawa, Ontario K1A OE7.

Pope, G.F.
Beak Consultants Limited
6870 Goreway Drive
Mississauga, Ontario L4V 1L9.

Redpath, D.K.
Lands Directorate
Pacific Region
Environment Canada
Room 400 - 1001 W. Pender Street
Vancouver, British Columbia V6E 2M7.

Roberts, G.
Department of Northern Saskatchewan
Box 5,000
La Ronge, Saskatchewan.

Robertson, J.
Inland Waters Directorate
Environment Canada
Ottawa, Ontario K1A OE7.

Robitaille, G.
Parks Canada
Department of Indian & Northern Affairs
Ottawa, Ontario K1A OH4.

Romaine, M.J.
Lands Directorate
Environmental Management Service
Environment Canada
1001 W. Pender Street
Vancouver, British Columbia V6E 2M7.

Runka, G.G. Chairman
British Columbia Land Commission
4333 Ledger Avenue
Burnaby, British Columbia V5G 3T3.

St. Amour, L.
Ministry of State for Urban Affairs
355 River Road
Ottawa, Ontario K1A OP6.

Schalkwyk, J.A.
Legal and Planning Branch
Room 318 - 99th Avenue and 109th Street
Edmonton, Alberta T5K 2E1.

Seifried, A.E.
Resource Coordinator
Alberta Department of the Environment
11th Floor, Oxbridge Place
9820 - 106th Street
Edmonton, Alberta T5K 2J6.

Stephansson, S.
Freshwater Institute
Fisheries and Marine Sreet
Environment Canada
501 University Grescent
Winnipeg, Manitoba.

Strang, R.M.
Faculty of Forestry
University of British Columbia
Vancouver, British Columbia V6T 1W5.

Swanson, W.
Lands Directorate
Environment Canada
Ottawa, Ontario K1A OE7.

Thie, J.
Lands Directorate
Environment Canada
20th Floor, Place Vincent Massey
Ottawa, Ontario K1A OE7.

Thomasson, R.D.
Man. Dept. of Mines, Nat. Res. and Environment
Box 16, 1495 St. James Street
Winnipeg, Manitoba R3H OW9.

Van Eyk, D.
Environmental Social Program - Northern Pipelines
Department of Indian & Northern Affairs
151 Slater Street
Ottawa, Ontario K1P 5M3.

Watson, G.H.
Canadian Wildlife Service
Environment Canada
16th Floor, Place Vincent Massey
Ottawa, Ontario K1A 0E7.

Wilmeth, R.
Plateau Archaeologist
Archaeological Survey of Canada
National Museum of Man
Ottawa, Ontario K1A 0M8.

Young, G.K.
Soils Branch
British Columbia Department of Agriculture
Kelowna, British Columbia V1Y 4R2.

Zoltai, S.C.
Canadian Forestry Service
Environment Canada
Northern Forest Research Centre
5320 - 122 Street
Edmonton, Alberta T6H 3S5.

ECOLOGICAL LAND CLASSIFICATION SERIES

* No. 0. Canada Committee on Ecological (Biophysical) Land Classification. 1979. Canada's Northlands (Second Edition). Proc. of a Technical Workshop — To develop an integrated approach to base data surveys for Canada's Northlands, 17-19 April 1974, Toronto, Ont. Comp. and ed. by M.J. Romaine and G.R. Ironside. 124p. Cat. No.: EN 73-3/0. Free.

* No. 1. Canada Committee on Ecological (Biophysical) Land Classification. 1977. Ecological (Biophysical) Land Classification in Canada: Proc. First Meeting Can. Comm. on Ecol. (Biophys.) Land Classif., 25-28 May 1976, Petawawa, Ont. Ed. by J. Thie and G. Ironside. 269p. Includes abstracts and some text in French. Cat. No.: EN73-3/1. ISBN: 0-662-00473-6. Free.

** No. 2. Jurdant, M., J.L. Bélair, V. Gerardin, and J.P. Ducruc. 1977. <u>L'inventaire du Capital-Nature: Méthode de classification et de cartographie écologique du territoire.</u> (English text in preparation). Cat. No.: EN 73-3/2F. ISBN: 0-660-00755-X. Price $7.00 (Canada); $8.40 (other countries).

** No. 3. Canada Committee on Ecologial (Bio-Physical) Land Classification. 1977. Ecological (Biophysical) Land Classification in Urban Areas: Proc. of a workshop, 23-24 November 1976, Toronto, Ont. Comp. and ed. by E.B. Wiken and G.R. Ironside. 167p. Includes abstracts and some text in French. Cat. No.: EN 73-3/3. ISBN: 0-660-01415-7. Price $4.00 (Canada); $4.80 (other countries).

*** No. 4. Lopoukhine, N., N.A. Prout, and H.E. Hirvonen. 1978. The Ecological Land Classification of Labrador; A Reconnaissance. 85p. and map. Cat. No.: EN 73-3/4.

** No. 5. Welch, D.M. 1978. Land/Water Classification: A review of water classifications and proposals for water integration into ecological land classification. 54p. Cat. No.: EN 73-3/5. ISBN: 0-660-10039-8. Price: $4.50 (Canada); $5.40 (other countries).

SÉRIE DE LA CLASSIFICATION ÉCOLOGIQUE DU TERRITOIRE

* N° 0. Comité Canadien de la Classification Écologique du Territoire. 1979. <u>Canada's Northlands (Second Edition). Proc. of a Technical Workshop — To develop an integrated approach to base data surveys for Canada's Northlands,</u> 17-19 avril 1974, Toronto, Ont. Comp. et éd. par M.J. Romaine et G.R. Ironside. 124p. N° de cat.: EN 73-3/0. Gratuit.

* N° 1. Comité Canadien de la Classification Écologique du Territoire. 1977. Classification Écologique (Biophysique) du Territoire au Canada: Compte rendu de la première réunion du Com. Can. de la Classif. Écol. du Terr., 25-28 mai 1976, Petawawa, Ont. Éd. par J. Thie et G. Ironside. 269p. Comprend des résumés et du texte en français. N° de cat.: EN 73-3/1. IBSN: 0-662-00473-6. Gratuit.

** N° 2. Jurdant, M., J.L. Bélair, V. Gerardin, et J.P. Ducruc. 1977. L'inventaire du Capital-Nature: Méthode de classification et de cartographie écologique du territoire. Texte en français. 202p. N° de cat.: EN 73-3/2F. ISBN: 0-660-00755-X. Prix $7.00 (Canada); $8.40 (autres pays).

** N° 3. Comité Canadien de la Classification Écologique du Territoire. 1977. Classification Écologique (Biophysique) du Territoire dans les Régions Urbaines: Compte rendu d'un atelier, 23-24 novembre 1976, Toronto, Ontario. Comp. et éd. par E.B. Wiken et G.R. Ironside. 167p. Comprend des résumés et du texte en français. N° de cat.: EN 73-3/3. ISBN: 0-660-01415-7. Prix $4.00 (Canada); $4.80 (autres pays).

*** N° 4. Lopoukhine, N., N.A. Prout, et H.E. Hirvonen. 1978. <u>The Ecological Land Classification of Labrador; A reconnaissance.</u> 85p. et carte. N° de cat.: EN 73-3/4.

** N° 5. Welch, D.M. 1978. <u>Land/Water Classification: A review of water classifications and proposals for water integration into ecological land classification.</u> 54p. N° de cat.: EN 73-3/5. ISBN: 0-660-10039-8. Prix: $4.50 (Canada); $5.40 (autres pays).

No. 6. Wiken, E.B. Ecological (Biophysical) Land Classification: An Analysis of Methodologies. To be published at a later date. Cat. No.: EN 73-3/6.

No. 7. Canada Committee on Ecological (Biophysical) Land Classification. 1979. Applications of Ecological (Biophysical) Land Classification in Canada: Proc. Second Meeting Can. Comm. on Ecol. (Biophys.) Land Classif., 4-7 April 1978, Victoria, B.C. Comp. and ed. by C.D.A. Rubec. 396p. Includes abstracts and some text in French. Cat. No.: EN 73-3/7.

The Ecological Land Classification Series is published by the Lands Directorate, Environment Canada.

* May be requested from:
Lands Directorate Information Officer
EMS Information Team
Environment Canada
11th Floor, Place Vincent Massey
Ottawa, Ontario.
K1A OE7.

** Available by mail from:
Printing and Publishing
Supply and Services Canada
Ottawa, Ontario.
K1A OS9.

*** May be requested from:
Lands Directorate
Atlantic Region
P.O. Box 365
Halifax, N.S.
B3J 2P8.

Numbers 1 and 3 are also available in microfiche, free of charge, and may be requested from:
Lands Directorate
Environment Canada
20th Floor, Place Vincent Massey
Ottawa, Ontario.
K1A OE7.

N° 6. Wiken, E.B. Ecological (Biophysical) Land Classification: An Analysis of Methodologies. A être publier plus tard. N° de cat.: EN 73-3/6.

N° 7. Comité Canadien de la Classification Écologique du Territoire. 1979. Applications de la Classification Écologique (Biophysique) du Territoire au Canada: Compte rendu de la deuxième réunion du Com. Can. de la Classif. Écol. du Terr., le 4-7 avril 1978, Victoria, C.B. 396p. Comprend des résumés et du texte en français. N° de cat.: EN 73-3/7.

La Série de la Classification Écologique du Territoire est publiée par la Direction générale des Terres, Environnement Canada.

* Il peut être obtenu en écrivant à:
Agent d'information de la Direction générale des Terres
Équipe d'information SGE
Environnement Canada
11ième étage, Place Vincent Massey
Ottawa, Ontario.
K1A OE7.

** En vente par la poste:
Imprimerie et Édition
Approvisionnements et Services Canada
Ottawa, Ontario.
K1A OS9.

*** Il peut être obtenu en écrivant à:
Direction régionale des Terres
Région de l'Atlantique
C.P. 365
Halifax, Nouvelle-Écosse.
B3J 2P8.

Les numéros 1 et 3 sont aussi disponible en microfiche (gratuits) et peuvent être obtenus en écrivant à:
Direction générale des Terres
Environnement Canada
20ième étage, Place Vincent Massey
Ottawa, Ontario.
K1A OE7.

Environment Canada | Environnement Canada

Lands Directorate | Direction générale des terres